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OF THE

GEOLOGICAL SOCIETY OF DUBLIN.

VOL. V.

1850-53.

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1853.

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AT

THE ANNUAL GENERAL MEETING,

HELD AT

35, TRINITY COLLEGE,

ON

WEDNESDAY, FEBRUARY 12TH, 1851,

LIEUTENANT-COLONEL PORTLOCK, R.E., PRESIDENT, IN THE CHAIR,

The following Report from the Council was read and adopted:

Report of the Council of the Geological Society of Dublin, for the Year 1850–1851.

THE Council presents to the Society the following Report as to its movements for the past year.

Eight new Members have been added to the Society, viz.:— Nathaniel Hone, Esq.; Francis Codd, Esq.; Thomas O'Brien, Esq.; Edward Grattan Holt, Esq.; Hans H. Allen, Esq.; Richard Hitchcock, Esq. (Assistant Secretary); Henry Head, Esq., M.D.; and Lord Talbot de Malahide.

Three Associates, viz.:—Alexander Jack, Esq.; Alexander Macdonnell, Esq.; and Thaddeus O'Malley, Esq.

Three Members have withdrawn:—A. W. Domville, Esq.; Frederick Burton, Esq., R.H.A.; and Thomas Oldham, Esq., F.R.S.

The withdrawal of the second the Council regrets to find has been caused by a severe family affliction by death; and in Mr. Oldham's case by his departure to India, to take the direction of the Indian Geological Survey. His absence cannot but be viewed as a loss to Irish Geology.

The Society does not appear to have sustained any loss by death during the year. It now numbers 4 Honorary Members, 35 Life Members, and 80 Annual Members, and 4 Associates; total, 123.

It is to be regretted that the opening of the advantages of the Society to the Class of Associates, at the nominal fee of *5s.*, does not appear to have been as fully appreciated as the Society expected.

No papers of adequate merits were presented during the year, and prior to December, 1850, to enable the Council to award any one of the three prizes offered publicly by the Society.

The Trust Fund from Life Compositions continues untouched.

The Council has taken measures for reducing the cost of publication of the Society's transactions in future, and, when the existing liabilities are paid, trusts that there will be no diminution in the extent or value of this department of our labours.

The Treasurer's account shows that our liabilities amount to about £66; that there is lodged in bank, exclusive of the Trust Fund from Life Compositions, about £30; and that the subscriptions due, and in process of collection, may be supposed capable of meeting the balance of claims at present against the Society.

The following lists contain the donations made to our library during the past year.

GEOLOGICAL SOCIETY.

DONATIONS RECEIVED SINCE LAST ANNIVERSARY.

1849.

Aug. 3. Geological Map of the County of Kildare. Presented by the Chief Commissioner of Woods and Forests, through Sir Henry T. De La Beche.

1850.

Feb. 22.—Quarterly Journal of the Geological Society of London, No. 21. Presented by the Society.

May 1.—Transactions of the Royal Scottish Society of Arts, Vol. III., Part 4. Presented by the Society.

June 4.—Quarterly Journal of the Geological Society of London, No. 22. Presented by the Society.

June 15.—Reports of the Dublin Natural History Society, Eighth and Ninth. Presented by the Society.

June 15.—Proceedings of the Royal Irish Academy, Part 8, Vol. III., Parts 1 to 3; and Vol. IV., Parts 1, 2. Presented by the Academy.

June 19.—Address to the Geological Society of London, Feb. 15, 1850. By Sir Charles Lyell, F.R.S., &c. Presented by the Author.

June 26.—Proceedings of the Royal Irish Academy, Parts 1 to 4. Presented by the Academy.

June 27.—Proceedings of the Literary and Philosophical Society of Liverpool, Nos. 1 to 3. Presented by the Society.

July 1.—Reports of the Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne, for the Years 1839 to 1849 inclusive. Presented by the Society.

July 9.—Memoirs of the Wernerian Natural History Society, Vol. VII. and Vol. VIII., Part 1. Presented by the Society.

July 12.—Proceedings of the Linnæan Society, Nos. 1 to 41, with List of the Society, 1849. Presented by the Society.

July 30.—Transactions of the Philosophical and Literary Society of Leeds, Vol. I., Part 1. Presented by the Society.

1850.

July 30.—Account of an Egyptian Mummy, presented to the Museum of the Leeds Philosophical and Literary Society by the late John Blayds, Esq. Presented by the Society.

July 30.—Reports of Council of the Leeds Philosophical and Literary Society, Nos. 5 to 7—11, 12—14 to 29 (Leeds, 1825–49). Presented by the Society.

July 30.—Reports of Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire, Vol. II. pp. 1–102, and Vol. III. pp. 1–108. Presented by the Society.

Aug. 29.—Quarterly Journal of the Geological Society of London, No. 23. Presented by the Society.

Sept. 6.—Athenæum, Annual Report, General Abstract of Accounts, &c., for 1849. Presented by the Club.

Sept. 16.—Proceedings of the Zoological Society of London, Nos. 1 to 154, 163, 164, and 177 to 189, with Reports for 1848 and 1849. Presented by the Society.

Sept. 18.—Memoirs of the Geological Survey of the United Kingdom; Figures and Descriptions Illustrative of British Organic Remains, Decade III. Presented by the Chief Commissioner of Woods and Forest.

Oct. 3.—Journal of the Royal Geographical Society of London, Vol. XX., Part 1. Presented by the Society.

Nov. 6.—Transactions of the Geological Society of London, Vol. IV., Part 2; Vol. V., Parts 1 to 3; Vol. VI., Parts 1, 2; and Vol. VII., Parts 1 to 3. Presented by the Society.

Nov. 13.—Report of the British Association for the Advancement of Science, for 1849. Presented by the Association.

Nov. 13.—Conybeare and Phillips' Geology of England and Wales, Part 1. Presented by Professor Oldham.

Nov. 13.—Dove's Maps of the Monthly Isothermal Lines of the Globe. Presented by Professor Oldham.

Dec. 11.—Proceedings of the Zoological Society of London, Nos. 190 to 200, with Reports of Council, &c. Presented by the Society.

Dec. 16.—Quarterly Journal of the Geological Society of London, No. 24. Presented by the Society.

Dec. 18.—Transactions of the Kilkenny Archæological Society, for the Year 1849. Presented by the Society.

Geological Society.—Abstract of Accounts for the Year ending February, 1851.

Dr.		£	s.	d.
To Life Subscriptions—				
Of Mr. W. S. Wilson,		5	0	0
Of Mr. N. Hone,		10	0	0
„ Payment by the Commissioners of Public Works for Furniture,		10	0	0
„ Admission Fees, per Annexed List,		8	0	0
„ Annual Subscriptions, Do.		66	10	0
„ Interest on Government 3¼ per cent. Stock, viz:—				
On £70 6*s*. 10*d*. for the half-year, to 6th April, 1850,		1	2	10
On £80 12*s*. 3*d*. for the half-year, to 10th October, 1850,		1	6	2
„ Received from the Rev. S. Haughton for Books,		1	0	0
		£102	19	0

12th February, 1851.

Cr.		£	s.	d.
By Balance due by the Society on the last Year's Account,		13	6	1½
„ Collector's Poundage,		3	14	6
„ Cost of £15 6*s*. 10*d*. of 3¼ per cent. Stock, at £96 2*s*. 6*d*., per Broker's Account,	£15 0 0			
„ Cost of £10 5*s*. 5*d*. Ditto, at £96 15*s*., per Ditto,	10 0 0			
		25	0	0
„ Sundry small expenses,		4	14	0
„ Assistant Secretary's Salary, half-year, to 14th Aug., 1850,	£10 0 0			
„ Sundry small expenses,	4 18 0			
		14	18	0
„ Assistant Secretary's Salary for half-year to 14th Feb. 1851,	£10 0 0			
„ Sundry small expenses,	1 12 6			
		11	12	6
„ Balance in the Treasurer's hands,		29	13	10½
		£102	19	0

Examined, J. PORTLOCK, *President*.

A Ballot then took place when the following Gentlemen were elected Officers of the Society for the ensuing Year:—

President:

LIEUT.-COL. PORTLOCK, R.E.

Vice-Presidents:

JAMES APJOHN, ESQ. M.D.
RICHARD GRIFFITH, ESQ. LL.D.
REV. H. LLOYD, D.D. S.F.T.C.D.
RT. HON. THE LORD CHANCELLOR.
THE ARCHBISHOP OF DUBLIN.

Treasurers:

WILLIAM EDINGTON, ESQ.
SAMUEL DOWNING, ESQ.

Secretaries:

ROBERT MALLET, ESQ.
REV. S. HAUGHTON, F.T.C.D.

Council:

C. W. HAMILTON, ESQ.
JOHN MACDONNELL, ESQ. M.D.
PROFESSOR HARRISON, M.D.
CHARLES P. CROKER, ESQ. M.D.
THOMAS HUTTON, ESQ.
ROBERT BALL, ESQ. LL.D.
ROBERT CALLWELL, ESQ.
PROFESSOR ALLMAN.
PROFESSOR HARVEY.
REV. J. A. GALBRAITH, F.T.C.D.
F. J. SIDNEY, ESQ. LL.D.
JOHN KELLY, ESQ.
BARRY D. GIBBONS, ESQ.
JOHN PETHERICK, ESQ.
JOHN KING, ESQ.

ADDRESS.

On addressing you again, Gentlemen, after a lapse of so many years, from this Chair, I may be permitted to express my satisfaction at seeing a Society of which I was an original member, and with which I have been so intimately connected, still successfully and vigorously pursuing its useful and honorable course; and, let me add, that personally I have an additional gratification in observing still amongst you so many of my old and respected friends, with whose names the labours and fame of the Geological Society of Dublin will ever be associated.

It appears to me that on an occasion of this kind I shall best consult the interests of Science, and the wishes of the Society, by briefly considering the objects which ought to occupy the attention of a geologist, and bringing before you some of them, illustrative of the philosophical results of geological inquiry, which are suggested by the subjects which have occupied our attention during the past Session. In pursuing the study of the history of the Earth, and as a student of that history we must consider the geologist, we are taught to recognise an intimate, though sometimes, it may appear, a mysterious and uncertain connexion between the mineral or inorganic, and the organic divisions of nature. From the rock to the plant, and from the plant to the animal, there is a continued chain, not of affinities but of dependencies, and on that account it is that the geologist is becoming, more and more, as knowledge progresses, the fellow-labourer of the botanist, the zoologist, and, even in more practical matters, of the agriculturist, the merchant, the miner, the quarryman, and, I will even say, of the soldier. Such is the result of a practical examination of our subject; but when it is looked at by the philosopher, he learns by the study of the earth many most interesting

and startling facts: in its crust he discovers evidences of successive disturbances on the one hand, and of the most harmonious arrangements on the other. He finds the proofs of the devastating influences of ancient volcanoes, earthquakes, torrents, floods, and other physical agencies, as well as the softening and order-giving effects of creative power and vital agencies. He observes that matter, even when not imbued with vital energies, is still regulated by fixed and unalterable laws, and he sees in the inanimate crystal, or the definite compound, proofs of a power as great, though it may not appear at first so striking, as that which is manifested in all the wonderful structures of the animal and vegetable kingdoms.

The knowledge he thus acquires leads him to recognise two distinct, though closely associated, branches of geological research; and, whilst he endeavours to study and describe the successive Faunæ and Floræ which his examination of the earth's crust has made known to him, he feels that it is also necessary to explain the mineral changes and unravel the phenomena connected with the destruction of one set of created and living beings, and the appearance and relations of a succeeding one.

Geology, therefore, divides itself into two great branches, physical or inorganic geology, and natural or organic geology, neither of which can be neglected without leading to an imperfect knowledge of the whole. The various accidents which have affected the crust of the earth; the elevations and depressions of portions of its surface; the intrusion of molten mineral matter, or its outpouring in lava currents; the mighty denudations which have swept away vast masses of strata; the decomposition and degradation of mineral masses; the deposition, induration, and metamorphosis of others; the veins which traverse the rocks, and the minerals which are collected in them: all these, and other phenomena, are connected with the great laws of matter generally, whilst the relics of past organic creatures, though also under the control of the laws of matter, contribute to the geologist a still higher knowledge, as they establish the modifying influences of vitality, acting also as if regulated by distinct laws. Whilst, however, there is a practical distinction between these two branches of our subject, it must be remembered that the laws of matter are

never suspended, and that they proceed undeviatingly towards the great end of their institution, notwithstanding the occasional peculiarities impressed upon them by vital action.

On this principle of division I shall class the several Papers read, namely—under physical geology, those which relate to any of the phenomena which are connected with the mineral condition of the earth, such as the intrusion of igneous rocks, the elevation or depression of the surface, the contortion of strata, the wearing action of currents and of glaciers, the mineral composition of rocks, the distribution of minerals; and in organic geology, every thing which relates to the inhabitants of the earth at successive epochs of its history.

An examination of the mineral crust of the earth has long since made manifest the disturbances which have affected strata, now apparently imbued with all the elements of stability; and it has been the constant aim of philosophers to connect the visible effects, as exhibited in induration, crystallization, structure, veins, faults, contortions, with some sufficient proximate cause. Heat and pressure acting on loosely aggregated mineral matter, heated steam, the undulatory movement of a liquid nucleus, the contraction of the crust resting on that nucleus, volcanic agencies in whatever way excited, earthquakes, &c., have all been tried in aid of explanation, and we may now add the attempt of Mr. Stevenson M'Adam, of Edinburgh,* to apply the theory of M. Boutigny d'Evreux, a French chemist, who has lately created much sensation by reviving our knowledge of a peculiar property of fluids, in what he calls the spheroidal state, and explaining by it many of those remarkable facts which in past ages appeared miraculous, such as the incombustible man, or the ordeal by fire in which the hand was plunged unhurt into a bath of molten lead. Mr. M'Adam thus states his view of the condition of the earth.

1. A central nucleus in a state of igneous fusion.

2. A crust, at a comparatively low temperature, the inner side of which is in the spheroidal state.

3. A space between the crust and the central nucleus, possibly filled with vaporized mineral matter.

* Jameson's Jour. Feb. 1851.

As one property of bodies in the supposed spheroidal state is repulsion of heat, it is presumed by Mr. M'Adam that the heat is always reflected from the inner surface of the crust, which, therefore, remains unaltered in temperature; and with this theory he combines the steam and chemical theory of volcanoes which are rendered intermittent by a sudden change from the spheroidal state to that of steam. In this explanation Mr. M'Adam takes for granted that M. Boutigny's theory of that peculiar condition of bodies which he calls spheroidal, has been fully demonstrated; but it is not so, as another explanation of the phenomena has been advanced, and is still maintained by that eminent chemist, Person. M. Boutigny considers that when a fluid is thrown upon any substance, whether solid or liquid, heated to a temperature exceeding the boiling point of the fluid, it does not pass immediately into the state of vapour, but into an intermediate, "the spheroidal" state, in which its temperature is considerably below that of its boiling point. When bodies are in the spheroidal state M. Boutigny also considers that caloric exercises a repulsive power, even at sensible distances, and in this manner he explains the well-known phenomenon of a drop of water remaining for some time on a red hot iron, as well as that of the incombustibility of the human hand when plunged into molten lead or iron, the *rationale* in the latter case being this, that the moisture of the hand supplies water which passes into the spheroidal state, at a temperature greatly below that of boiling water, when its caloric repels the metal, and thus preserves the hand from contact with it.

In illustration of this theory M. Legal has subsequently shown that the only precaution necessary in such experiments is to use for the protecting fluid one of which the boiling point is considerably below that into which the hand is to be plunged; ether, for example, if it be intended to try the effects of boiling water: so that if the hand be dipped into ether, and then into boiling water, the effect will be a sensation of coolness and not of heat.

Ingenious, however, as the explanation of M. Boutigny undoubtedly is, it requires the admission of a new property in matter, and as all hypotheses based on such an assumption require to be closely scrutinized, the doubts of M. Person merit attention, and his explanation careful consideration. M. Person begins by reject-

ing the supposed spheroidal condition, and the consequent repulsive action of caloric at sensible distances, and explains the phenomena thus: when a fluid is projected on a highly heated surface a portion of vapour is immediately formed, which, by its elastic tension, separates the rest of the fluid from the heated body; and in like manner, when the moist hand is plunged into the molten metal a film of vapour is formed between the metal and the hand, or rather between the metal and the remaining portion of the fluid on the hand, and as the latter is a slow conductor of heat, some time must elapse before the hand will itself be seriously affected by it. Whilst, therefore, a theory is yet in uncertainty, it seems scarcely wise to refer to it for an explanation of great natural phenomena; but under any view of it may there not be a doubt as to its application in the manner proposed by Mr. M'Adam? How could the interior of the crust have been brought into the supposed spheroidal state, and a separating film of vaporized mineral matter generated on M. Boutigny's principles, since it is reasonable to suppose that originally the crust and nucleus were only continuous parts of one mass?

How could water pass through such an atmosphere of vaporized mineral matter without being reduced to vapour long before it came in contact with the solid nucleus?

Putting aside, however, the conditions of an independent crust, with an inner surface in the spheroidal state, and a separating atmosphere of vaporized mineral matter, as resting solely on hypothesis, the properties of matter in a fluid state, as exhibited by M. Boutigny, may be useful in connecting steam with terrestrial disturbances, as it does appear possible that a column of water penetrating by channels in the superficial crust, might come in contact with a portion of the nucleus, at a vastly higher temperature than its boiling point, when vapour would be generated of sufficient tension to keep the rest of the column free from actual contact. This state of things would continue until the vapour, having gradually increased in quantity and in tension, had acquired a force sufficient either to burst the retaining crust, or to force up the column of water.

The phenomena of physical geology are invested with so many difficulties that their investigators have hitherto been few,

and there has been a disinclination on the part of many eminent geologists to admit them as a branch of the science; but surely no one who looks at the subject in its grandest point of view can adopt such opinion, or refrain from attempting to unravel the difficult as well as the easy problems of creation. I need here only refer to the labours of Mr. Hopkins as a proof of what may be done in such an inquiry, and I congratulate the Society that one of its own members has been willing to pursue so arduous an investigation. In attempting it Mr. Barrington has necessarily been obliged to assume some basis of calculation, and then to ascertain how far the facts before him were reconcilable with it; he has thus assumed that lateral pressure, or a disturbing force acting laterally, has been the cause of contortions in strata, and then, by mathematical analysis, demonstrated that such pressure—that, for example, which would accompany the intrusion of large quantities of liquid matter amongst the more solid strata—is sufficient to produce, and would produce, contortions of the description and forms actually observed in the strata of the earth. In this investigation Mr. Barrington assumes, that the stratum or bed acted upon is always slightly bent, or in other words, never in the same mathematical plane as the force acting upon it; and this assumption may be at once admitted, as in nature the beds can never be in the same plane as the lateral force acting upon them, for if we suppose, as is most probable, that the pressure is the result of a forcible intrusion of igneous mineral matter amongst them, the necessary rupture of the beds must be accompanied by a disturbance of their original position, even if it were supposed to have been coincident with the plane in which the pressure resulting from that intrusion acted.

Mr. Barrington on this hypothesis determines two formulæ, the one giving the amount of normal pressure exerted against the curve of the bed or stratum, at any one point which is proportional to the force applied directly and inversely as the radius of curvature at the point; and the other the amount of the force. It is evident then, that if some absolute values could be determined of the amount of the original pressure and of the resistances, the precise bends or curves of the strata might be also determined. This, however, is not here attempted, but presuming certain conditions of yielding, Mr. Barrington shows the several modifications of the

curve which would result from them. In the first instance this is taken as a single curve, but if the force be considered as transmitted on, without diminution from friction, a second, and a third, and indeed a series of curves would follow. The friction, however, of the beds must be very great, and the compressive force will be gradually diminished by it, so that the magnitude of the curves or contortions will also diminish. When the strata once begin to move and assume the curvilinear shape they will continue to bend if the pressure continue and be confined to this portion of the strata, until fracture takes place, and no second bend would be formed until then; but if the friction has not prevented the transmission of the force so as to act on the more advanced parts of the stratum, a second and a third bend may begin to be formed simultaneously with the first move of the original bend, and as each of these may proceed to its point of yielding or fracture, a series of broken curves may be formed. There can be little doubt that the results here stated are quite in harmony with the phenomena of contorted stratification; and it will be well also to bear in mind that there is no necessity for supposing that the strata we now see so singularly contorted were in their present state of induration, and even crystallization, at the time of their disturbance. On the contrary, it is far more probable that they were then beds of loosely aggregated materials, and after contortion were reduced by metamorphic action to their present mineral condition. I have said that Mr. Barrington was obliged to assume the existence of lateral pressure, and I have suggested as one, at least, of its proximate causes, the intrusion of melted mineral matter amongst the strata of the earth, accompanied by rupture or disturbance of its crust.

That such intrusions as exhibited by volcanic phenomena have taken place at all geological ages, and still continue to occur, must I think be now admitted by every geologist. Professor Oldham refers those of Wexford to the Silurian epoch. In his notice of the Wexford geology, which was his last contribution to our Society, he states, that "the slate rocks, east of the town of Wexford, towards Carnsore Point, belong to the middle portion of the series, and are not, as shown in previous maps, Cambrian, or the lowest beds. This portion is characterized by a great abundance

of trappean rocks, volcanic ashes, breccias, &c., accompanied by many fossiliferous beds."

In my own brief Paper I have quoted an example from the carboniferous slates of Bantry Bay, in which the intrusion of igneous rocks is exhibited on the shore, as well as the most remarkable contortions of the strata at Whiddy Island opposite to it.

Some of the basaltic eruptions of the North of Ireland were of the liassic, others of the cretaceous, and others probably of the tertiary epochs.. The disturbances described by Sir R. Murchison in his Paper* on the Vents of Hot Vapour in Tuscany, have occurred in parallel lines, and were accompanied by erupted matter, at successive epochs, "and with the simultaneous production of great divergent elevations, in Italy and the Alps, even after the deposit of the nummulite or eocene formation." And again, M. Rochet d'Hericourt describes that portion of Abyssinia which lies between Massenah and the Red Sea, as in a continued course of elevation, a conclusion which he establishes from many facts, such as the drying up of once abundant springs and numerous proofs of volcanic action in hot springs, ancient craters, &c.†

The connexion of the eruption of igneous rocks, or of mineral matter in a fluid or semi-fluid state, with the disturbance of the earth's crust, and the contortions of its strata, is so important an element in geological reasoning, that it is desirable to dwell for a few moments upon it. Doubtless the expectation of finding erupted igneous rocks always at the point where the contortions of the strata are at their maximum, has led to frequent disappointment; but if it be considered that on the principles set forth in Mr. Barrington's Paper, the impulsive force exercised by the igneous matter in its course upwards, would act laterally in a diagonal manner on the superficial strata, it will be easy to conceive that the yielding beds would be forced laterally forwards and upwards, and by the contorting consequent on a resistance to the upward movement from the superincumbent weight, would be packed into a much less horizontal space than that which they occupied previously. It is therefore in the axis of disturbance, whether found in an anticlinal mountain valley, or in a plane at the outcropping edges of the disturbed strata, that

* Geol. Journal, Nov. 1850. † Comptes Rendus, Feb. 1850.

evidences of eruption should be sought. In Bantry Bay I have pointed out examples of the intrusion of igneous rocks amongst the metamorphosed schists of the shore, whilst the great contortions are in Whiddy Island, distant from it about a mile, the actual focus of disturbance being probably under the intervening channel.

In Sir Roderick Murchison's Paper before referred to, that able observer has shown that the result of igneous eruption has been in the case of the Alps and Apennines, divergent lines of simultaneous disturbance.—"In the chief range of the Swiss and Austrian Alps, the greatest changes of metamorphosis, elevation, depression, and contortion have been determined upon lines having on the whole an E.N.E. and W.S.E. direction, whilst in the Apennines the same changes have occurred at the same periods in linear bands trending generally from N.W. to S.E., and bearing round to a meridian strike as they approach the direction of the ancient and palæozoic rocks of Corsica and Sardinia."

The centre of disturbance Sir R. Murchison places to the N.W. of Genoa, from which region of chief eruption, "trends, from N.W. to S.E., the serpentine bosses of the Apennines, between Bologna and Florence, which, though divergent from the line of the Apuan Alps and Tuscan Maremma, are exactly coincident with the major axis of the Apennines, or great back-bone of Italy, the culminating point of which, as at the Gran Sasso d'Italia, 9,530 feet above the sea, are composed of eocene and cretaceous rocks reposing on jurassic." In endeavouring to trace back these disturbances to the earliest epochs, it appears that, in the line of Sardinia and Corsica, there is a meridian chain of ancient crystalline and silurian rocks, overlaid by a coal formation, and, therefore, "that in that line, as well as in the line of the Alps, the later serpentinous eruption had found its issue along a line of fracture coincident with the direction which had been impressed upon these lands at a very remote period, or with the direction of a primeval coast, on which were found strata containing palæozoic fossils. The peculiar igneous rocks which have in this case been the disturbing agents, are the gabbro rosso, a red felspathic rock, with a concretionary and variolitic structure, resembling some of our amygdaloids, and serpentine;

and whilst in the Alps no trace of subaerial volcano has been found, and the youngest igneous rocks appear to have been those which traverse the older tertiary deposit, in the Apennines there are proofs of copious volcanic eruptions, extending in Vesuvius up to the existing epoch; so that Sir R. Murchison comes to the important conclusion that "subterranean igneous forces develop their action at successive epochs along the same established bands of active change in the crust of the globe." In determining, however, the exact limits of successive epochs of disturbance, there is a source of error which appears to have been overlooked. It is, for example, generally assumed that the disturbance must have taken place subsequent to the epoch of the broken and inclined strata, and anterior to the overlying horizontal strata, but this does not appear an absolutely necessary consequence, as it is highly probable that in many cases the contortions may not have extended into the uppermost strata, but have ceased at that point where the weight of the superincumbent mass was not sufficient to prevent its yielding to the pressure from below and moving upwards. In such a case as this the unconformable position of the overlying strata would be no proof that the disturbance which had contorted and tilted up the beds under them was in date anterior to their deposition; and, at the same time, it would be unnecessary to seek for a second depression or subsidence to account for their deposition. It is by no means my intention to refer all unconformable stratification to the cause I have here pointed out, although I think that some examples may be best explained by it, as well as many of the phenomena of denudation in which portions of the unconformably overlying strata are left as caps on elevated and exposed crests, whilst other portions either remain in the valleys below or have been swept away.

That remarkable dependence of the form of a palæozoic coast on a line of intrusion of igneous matter, at a still more remote epoch noticed by Sir R. Murchison in the paper above referred to is generalized by M. Agassiz in his recent work on America.* Having first laid down as an established fact that the form and peculiarities

* Lake Superior; its Physical Character, Vegetation, and Animals. Boston: 1850.

of the world's present surface are principally due to the elevation of mountain chains and the rise of extensive tracts from plutonic and volcanic action, he enters on the inquiry whether the subordinate features of a country are also to be ascribed to similar geological phenomena. The lakes of America, he observes, are excavated chiefly between the plutonic masses rising north, and the stratified deposits south of the primitive range; Lake Superior filling a chasm between the northern granitic and metamorphic range, and the oldest beds deposited along their southern slopes in the primitive age of the American continent; Lakes Huron and Michigan filling up cracks which run at right angles with the main northern primitive range, and which owe their origin to the elevation of the chains north of Lake Huron and Lake Superior; whilst Lakes Ontario and Erie run between successive sets of beds of the same great geographical period, or in a manner parallel to the first great depression occupied by Lake Superior. So far the connexion of the form and position of the lakes is with the greater exhibition of disturbing forces, which has resulted in the elevation of mountain chains, the intrusion of plutonic rocks, and the metamorphoses of the disturbed strata into crystalline rocks; but M. Agassiz carries the operation of such forces still further, and explains by it the minor modifications of the coast line of Lake Superior, as even the greatest complications in the outline of the shores can be accounted for by the combinations of dykes intersecting each other in different directions. These dykes he found arranged in different systems, each having its peculiar direction and peculiar mineral composition—a fact of very great interest. The dykes, which run north and south, forming several inlets, and intersecting the large Island of St. Ignace, consist of very hard, tough, unalterable hornblende trap, of a crystalline aspect and greyish colour: those which run east and west, determining the direction of a considerable portion of the coast, which it sometimes intersects in parallel lines, consist mostly of a greenish trap extensively injected with epidote; and those which determine the form of the north-eastern coast run N.N.E. to S.S.W., and consist of a pitchstone trap, like black glass, which, though externally very hard, readily decomposes, and gives rise to deep coves, narrow inlets, and small caves,

highly characteristic and picturesque. The north-western shore, which generally trends from N.E. to S.W., is greatly modified by the intrusion of igneous matter, as exhibited in three systems of dykes which, intersecting each other at acute angles, give rise to a similar disposition of the coast line. One of these is a black trap, and runs nearly N.E. and S.W.; another, running exactly N.E. and S.W., is rich in copper ores, and full of spathic veins; whilst the third runs E.N.E., and is of a light grey colour, without epidotic injections. In addition, therefore, to probably two other less-marked systems, there are six distinct systems of dykes, which contribute mainly to the formation of the northern shore of Lake Superior, viz:—No. 1, running E. and W.; No. 2, N. 30° W.; No. 3, due N. and S.; No. 4, N. 30° E.; No. 5, E. 30′ N.; No. 6, E. 45° N.: and it is by these six distinct systems of dykes, with peculiar characteristic trap, which form ridges parallel in the same system, but varying in different angles between the different systems, that the northern shores of Lake Superior have been intersected, and the whole tract of rock over the space which is now filled by the lake so cut up as to have destroyed its continuity. Depressions were thus produced, and an excavation gradually created which now forms the lake; and this process of intersection by the injection at successive periods of different materials, which has given to the lake its present outline, has evidently modified, at various epochs, the relative level of sea and land, materially affecting the deposition of its shore drift, and producing the successive amphitheatric terraces which border at various heights its shores. This repetition of successive eruptions of igneous matter in the same district is also stated by M. Rozet, in his paper on the Pyrenees,* where he describes two granitic eruptions—the one anterior to the transition (*id est*, Cambrian and Silurian) epochs, the other posterior to the cretaceous epoch, and mentions some curious facts illustrative of the actual condition of the granite at the time of eruption—namely, whilst fragments, more or less rounded, of granite are found imbedded in the arenacious strata of the transition epoch which overlie the greater masses of the plutonic

* Comptes Rendus. December, 1850.

rock—an example remarkably in accordance with the one afforded by the fragments of granite in the neighbourhood of Dublin—large blocks of the cretaceous limestone are found imbedded in the granite of the second eruption, as if that rock, in a semi-fluid state, had enveloped them.

It is certainly impossible to study such cases, and they might be multiplied, without agreeing with Sir R. Murchison that the outpouring of liquified mineral matter, and the disturbance of the strata, have taken place at successive epochs in lines differing but slightly in direction. In that conclusion, however, both Sir R. Murchison and Professor Agassiz have been anticipated by that most philosophical geologist, M. Elie de Beaumont, who, in pointing out nearly twenty years ago that systems of mountains of different ages have sometimes very nearly the same directions, applied to this fact the expressive term "periodic" return of directions, and understood by it that systems of mountains were not disposed by chance, as regards their relation to each other, on the surface of the earth, but were arranged in conformity with some definite law by which Nature, in producing them, was constrained to return, after certain intervals, nearly into the same directions or lines of operation.

Since M. Elie de Beaumont advanced this important proposition, and first explained his great theory of a definite system of elevations corresponding to successive geological epochs, and manifested in certain mountain chains, great information has been continually acquiring, and yet there has been little occasion even to modify the views of this author. M. de Beaumont considers the relative ages of twenty systems of mountains to have been determined with tolerable precision; namely, those of La Vendée, of Finistère, of Longmynd, of Morbihan, of Hundsrück, of the Ballons, of Forez, of the North of England, of the Low Countries, of the Rhine, of Thüringerwald, of the Côte d'Or, of Mont Visó, of the Pyrenees, of Tatra, of Sancerrois, of the western Alps, of the principal Alps, and of Ténare; and adds to them the system of Verens, the age of which, though less ancient than the lower chalk, is not accurately determined. M. Durocher has also proposed several other new systems which he has observed in Scan-

dinavia. The object of M. de Beaumont in his later inquiries* is, to ascertain whether those several systems of mountain chains, each of which is represented by a great circle of the earth oriented at some point of its curve—as, for example, that of the Rhine at Strasburg, where its direction is N. 21° E.—can be represented by any definite or geometric arrangement of intersecting planes. Considering, then, the 21 great circles as mountain systems, which have been accurately determined, each of them, if prolonged, would cut the other twenty in two different and opposite points, so as to produce altogether 420 different angles, or 210 angles in one hemisphere. These angles M. de Beaumont first determined from the known orientation of the several great circles or systems of mountains, and then plotting them on paper he found that they grouped themselves within very limited spaces, leaving large blanks between, and were thus entirely in conformity with natural appearances. The object was now to represent this fact by some definite geometric arrangement, so as to ascertain whether the planes adopted theoretically could by these intersections produce the angles which had been observed. After several unsuccessful trials, M. de Beaumont considered the results of the intersections of fifteen great circles, cutting each other in fives, at angles of thirty-six degrees, and dividing the surface of the sphere into one hundred and twenty rectangle scalene triangles, equal in surface and symmetrical in pairs, which may either be adjusted into thirty lozenge-shaped figures, twenty equilateral triangles, or twelve regular spherical pentagons, which latter arrangement M. de Beaumont adopted, and calls the resultant division a pentagonal reticulation. The pentagons meet at angles of 36°, 60°, and 90°, so that these angles and 72°, or the double of 36°, are the only angles which this fundamental reticulation affords; and, therefore, would not correspond to the more complicated system of mountains without the systematic introduction of auxiliary circles. To determine this interpolation M. de Beaumont first takes into consideration the intersections at an angle of 90° of the primary great circles of the

* Comptes Rendus. September, 1850.

pentagonal net; and as the three planes of each of the tri-rectangular systems which they produce, may be considered respectively parallel to the six faces of a cube, the centre of which is the centre of the sphere, and as the five cubes thus referred to may be represented by one cube which had turned 180° round each of the diagonals, M. de Beaumont represents the cube in each of its five positions as the nucleus of a regular crystalline system, composed of the faces of the octahedron, rhomboidal dodecahedron, pentagonal dodecahedron, &c., and other forms, which a regular crystalline system comprises. Then, imagining planes drawn through the centre of the sphere parallel to the several faces of the crystalline type, the result is an infinite number of great circles co-ordinated in the sphere with a perfect regularity and symmetry peculiar to the primary pentagonal net. This M. de Beaumont calls the complete pentagonal reticulation. Studying first, then, the combination of the primitive circles with those resulting from planes drawn parallel to the faces of the octahedrons and to those of the rhomboidal dodecahedrons, there are fifty-five circles, the intersections of which produce nearly all the angles which have been observed, at least all superior to 20° or 30°. By the introduction of other circles corresponding to various pentagonal dodecahedrons, trapezohedrons, &c., new combinations are obtained, all of which continue to exhibit the same tendency of grouping themselves in correspondence with the angles, obtained by observation. M. de Beaumont justly observes, that without doubt many new systems of mountains or lines of disturbance have yet to be discovered, and others will, in course of time be produced, so that the geometric exhibition of phenomena still imperfectly known or developed must, of course, be itself imperfect; but he adds, that if the fifteen primitive circles of the pentagonal net be really considered as a just representation of the primitive form of the network of mountain systems all other subsequent systems may be reproduced by introducing into the pentagonal system the auxiliary circles described above, which are, as it were, representatives of the planes of decrement in minerals.

M. de Beaumont illustrated this truly beautiful theory by the tri-rectangled triangle formed by the great circles of the mountain

systems of Tenare, of the principal Alps, and of the volcanic "trainée" of the Andes and Japan, which triangle is composed of one great circle of the fundamental pentagon, and of two circles dependent on rhomboidal dodecahedrons; and he observes, that though much has yet to be done to determine every minute detail, and to fill up the deficiencies of observation, so as to be able to deduce the several lines of systems by the determination of the angle of one pentagon, and the orientation of one great circle, he feels justified in assuming that the principle of symmetry connected with the pentagonal network does actually exist in nature. To explain this arrangement M. de Beaumont refers to the theory of the progressive secular refrigeration of the internal mass of the earth, and shows that the pentagon here takes the place of the hexagon, which is the prevailing form assumed by matter when splitting or cooling into minor masses, as in basalt. The fifteen great circles which divide the sphere into twelve regular pentagons are the lines of least contour, and would be those of easiest fracture, so that if all the corrugations or ridges of the earth had been produced at once, they would have probably conformed to these circles; but the systems of mountains were produced at different times, and the auxiliary circles were, therefore, probably necessary to connect them as intermediate systems with one or other of the fundamental circles. If such be the case we have, as it were, a key to the mode in which nature, since the earth began to cool, has maintained a species of secular harmony in its results. I cannot too strongly recommend to the able mathematicians of our Society a careful study of this theory of M. de Beaumont.

It will be observed that, except in noticing the paper of Mr. Stevenson M'Adam, little reference has been made to the causes of the great phenomena referred to. The basaltic dyke, the lava current, the contortions of rocky strata, the shocks of earthquakes, elevations and depressions of strata, are all effects, sometimes simultaneous, at other times successive, of some one or more great causes. Whilst, however, these great geological facts cannot be classed with ultimate causes, they are often secondary or proximate causes; and there is a tendency occasionally in some to produce the others. It is thus that the forcible intrusion of

molten igneous matter, as exhibited in dykes, &c., may have produced, as we have already observed, contortions of strata; and the rending of the crust of the earth, which accompanied such intrusion, may, in like manner, have originated the earthquake, which, in the progress of its shock, or of the earth-wave, became subsequently a proximate cause of elevation and subsidence. The phenomena of earthquakes have, from their close connexion with other geological phenomena, excited renewed interest and attention amongst geologists; and we are indebted to our member and late president, Mr. Robert Mallet, for a very learned Report on the subject,* from which I shall deduce some few useful remarks. Mr. Mallet commences his Report with a careful investigation of the history of his subject, and adopts, as the basis of his own propositions, the theory of Dr. Young and Gay Lussac, whose words he quotes. Gay Lussac states: "An earthquake is, as Dr. Young has well said, analogous to an undulation of the air, and is a very powerful sonorous wave excited in the mass of the earth by some disturbing cause, and which would propagate itself with the same velocity as sound;" and having illustrated the manner in which all the particles of a solid mass may be thus shaken by a reference to the shaking of large buildings on the passage of a waggon over the pavement, and other examples, adds—"In a word, earthquakes are no more than the propagation through the mass of the earth of a commotion, which, if not interrupted by cavities, would be extended proportionately further, as the earth itself is more homogeneous."

Mr. Mallet developes this idea of that great philosopher Dr. Young, and of the admirable French chemist—to both of whom he ascribes the highest praise—in the fullest manner, and supports and illustrates it by a mass of facts and arguments. The most important of his propositions are these:—The shock or earth-wave is a true undulation of the solid crust of the earth. The earth-wave or shock has in all cases a true wave form upon the surface of the earth, and when its direction of translation is *quam proxime* horizontally along the earth's surface, the crest of

* First Report on the Facts of Earthquake Phenomena: being Part of Report of the British Association for the Advancement of Science. 1850.

the wave advances along a given line, and parallel to itself. The earth-wave or shock is a motion of great velocity, and occurring during a very short moment of time at any given spot. The motion of translation of the earth-wave or shock is rectilinear and not curvilinear. The direction of translation of the earth-wave or shock varies from vertically upwards to horizontally, or nearly horizontally, in any azimuth. The earth-wave or shock has determined dimensions in height and breadth, or in altitude and in amplitude, and these are dependent upon the force of the original impulse, the nature of the materials through which it passes, and the distance it has travelled. The direction and velocity of translation of the earth-wave or shock change occasionally in passing from the boundaries of one formation to those of another. The time of transit of the sound-wave (which frequently, not always, accompanies the earth-wave) will manifestly differ, whether it reach the ear through the sea or through the solid land; in the former case its rate will be about 4,700 feet per second, if received through air about 1,140, and if through rocks or formations as follows :—

Lias Limestone,	3,640	per second,
Coal Measure Sandstone,	5,248	„
Oolite,	5,723	„
Primary Limestone,	6,696	„
Carboniferous Do.,	7,705	„
Hard Slates,	12,757	„

For granite and igneous rocks there are as yet no data, but the rate will be greater than in any of the preceding.

These propositions and experimental results are of the highest importance, and will, doubtless, when combined with further experiments on the passage of the wave through variously compressible substances, remove much of the obscurity which yet hangs over this great subject.

Mr. Mallet carefully and properly separates the phenomena of earthquakes, which he considers only part of the effects of some great disturbing force, from other effects, such as elevation and depression, which may either proceed from a similar or still more powerful force; and considers the earthquake as generally tend-

ing rather to depress and break up than to elevate the crust of the earth. In this view he is, doubtless, in the main correct, as the very idea of a wave implies undulation, not permanent elevation, of the surface; but, at the same time, this effect must be materially varied in passing through compressible strata, as in that case a certain amount of compression may be attained before the vibration is fully transmitted; and as the compressed stratum may never return to its original bulk, it is not improbable that it may have been squeezed partly upwards, and have continued after the shock elevated. In like manner the partial yielding of compressible strata may produce nearly the same effect on the more solid rock, as a sudden cessation of the vibrating material at the edge of a precipice has been shown to do, and be the cause of fractures or chasms. If so, such cracks or chasms will often explain the local structure of the crust of the earth when hidden from the eye by superficial deposits. May not, indeed, the whole progressive impetus of the wave be absorbed in this compressing and contorting action, and the undulation be at last brought to rest? I have thought it necessary to dwell so long on this interesting portion of our fellow-member's able Report, as it specially relates to the facts of earthquakes, and comprises many examples of their secondary effects, which are particularly valuable to the geological student; but the author does not confine himself to the detail of facts, as he endeavours also to account for them, and to give some reasonable account of their production. In this he concurs with Mr. Stevenson M'Adam, and seeks his explanation in the properties of steam. "In general," he says, "the average of numerous narratives seems to give from three or four to fifteen seconds as the duration of the great shocks, from two to ten or fifteen minutes for that of the powerful vibratory shakings, and an unlimited or, at least, uncertain time for slighter tremors afterwards. What sort of impulse then will be competent to account for this general order of succession? I believe it will be found either in the sudden bringing into contact, under pressure, of large ignited surfaces with cold water, or the blowing through and into cold water of volumes of steam under pressure, and this steam suddenly condensed therein." And again—"Briefly, then,

it seems to me that, however modified, the immediate impulses producing earth-waves of shock are due—

"1. To the sudden formation of steam from water previously in a state of repulsion from the heating surfaces (spheroidal state), and which may or may not be again suddenly condensed under pressure of sea water.

"2. To the evolution of steam through fissures, and its irregular and per saltum condensation under pressure of sea water.

"3. To great fractures and dislocations in the rocky crust, suddenly produced by pressure acting on it from beneath or in any other direction.

"4. Occasionally, but rarely, to the recoil from mighty explosive effects of volcanic foci, as when a mass of rock weighing 200 tons was shot from the crater of Cotopaxi to the distance of nine miles (Humboldt); or when nearly one-half of the crater of Vesuvius was blown away."

I have already expressed my doubts of the expediency of appealing to a disputed property of matter in explanation of earthquake or other phenomena; but it is necessary to add some few words in reference to Mr. Mallet's mode of treating the subject. "When an irruption," Mr. Mallet observes, "of igneous matter takes place beneath the sea bottom, the first action must be to open up large clefts or fissures in its rocky material, or to lift and remove its incoherent portions, such as sand, gravel, &c. The first portions of water that gain access thus to the ignited surfaces, repelled by their heat, are brought into that peculiar state which Boutigny and others have called spheroidal. While in this condition their intestine motion may be great, but little steam is generated; and while this is the case no impulses will ever be conveyed to a distance, but only those tremblings or vibrations which precede the shock," &c. Before proceeding further it is right to ask by what force the irruption of igneous matter was produced, and how it could take place without some *previous* rupture of the earth's crust. But whether the rupture were previous to or simultaneous with the irruption, it is evident that the rending of the rocky materials of the sea-bottom must be attended with a jar or vibration through the solid crust quite sufficient to account for an earthquake or earth-wave, even though it may be followed up by

other shocks and vibrations from other causes, so that the third cause cited would always precede the others. Mr. Mallet proceeds—"But no sooner has the surface of lava become cooled to the point at which repulsion ceases, and the water altering its state comes into close contact with the heating surfaces, than a vast volume of steam is evolved explosively, and, blown off into the deep and cold water of the sea, is as instantly condensed; and thus a blow or impulse of the most tremendous sort is given at the volcanic focus, and being transferred outwardly in all directions, is transmitted as the earthquake shock." I fear, as I have stated in my remarks on the views of Mr. Stevenson M'Adam, that this explanation cannot be admitted without a much more accurate knowledge of the property of water in the spheroidal state than is at present possessed: and here also, as in the previous case, the mode of bringing such property into action seems obscure. Is it, for instance, with matter or lava which has been erupted that the water comes into contact, or is it with the molten matter within the volcanic focus? If with the lava erupted and spread out on the sea bottom, how can such results follow as those described?—or even were they possible, would not the sea-wave precede the earth-wave, and greatly exceed anything of which there is experience or evidence? If, on the other hand, the water be supposed to penetrate into the volcanic focus, and to come in contact with the molten matter within it, it is difficult to understand that diminution of temperature which is said to result in a cessation of the supposed repulsive action of caloric. If the phenomena attributed by M. de Boutigny to bodies in the spheroidal state be due to the repulsion of caloric, that power is exercised through a very great range of temperature, as, for example, it acts both when the damp or moistened hand is plunged into a bath of molten iron at a very high temperature, and into a vessel of boiling water at a comparatively low one. In the latter case the hand will be partially protected when moistened with water only, though there will be a sensation of heat; but when moistened with ether there will be a sensation of cold. Something more, therefore, than the mere abstract repulsive action of caloric is necessary to explain the effects referred to by Mr. Mallet on this theory; nor do I see in any of the experi-

ments evidence that such repulsive force, if existing, is of such magnitude as would resist the pressure of immense columns of water, and keep the fluid at a distance sufficient to stop, or at least to retard, for a considerable time, the transmission of heat. The views of M. Person on the subject I have already stated; and I can only repeat that it will be wise to refrain from adopting, as an explanation of some of the grand phenomena of the earth, a theory deduced from experiments on matter, conducted in comparatively a micrometric manner. How, then, are we to explain the convulsive shock of the earthquake, or the forcible protrusion of melted stony matter in the basaltic dyke, or the lava stream? The earthquake, I ascribe, with Mr. Mallet, to the rending asunder of the rocky crust of the earth. But by what force was that crust thus torn asunder, and streams of mineral matter forced through it? Mr. Mallet appears to adopt electric agency as the great final cause which has produced such results. "Thus, then," he says, "ignorant as we are of all within the outer surface or skin of our globe, we are compelled to see the close connexion of these mighty heating powers, in which ignition is present on the vastest scale, *yet without combustion*, with the forces of terrestrial electricity and magnetism—forces which are those alone that, within the range of our observation, are mutually convertible, and both convertible into heat. Currents of both we know are ever passing, with variable activity, through enormous volumes of the earth's crust, the different parts of which possess very different conducting powers. Can it be that these currents, constrained to pass through narrow and bad conductors, at vast depths in some formations, ignite them in their progress? Will it be found that the great lines of volcanic activity (as dreamed of by Bylandt) are in some way connected with those of terrestrial magnetism?—are possibly normals to the surface curves of equal magnetic intensity? A glance at one of Gauss's magnetic maps, and at another of the great bands of active volcanoes on our planet, almost forces the mind into such conjectures." It has long been felt by physical geologists that those great fundamental forces which, under the names of electric and magnetic fluids, can be traced throughout the limits of our earth's sphere, must share with gravitation in the regulation of

its material phenomena; but as yet the difficulty of connecting the known with the unknown, the experiment made in the laboratory with the great cosmical effects which the crust of the earth exhibits, has been so great that little advance has been made, excepting in the case of mineral veins, beyond conjecture. The time, however, is fast approaching when decided conclusions will be drawn from facts, and electricity and magnetism be either admitted as great cosmical forces, or finally rejected. I fully anticipate, as I have on previous occasions conjectured, that the result will be affirmative; and it appears to me probable that a clue will be found to unravel the mystery in the newly discovered form of these forces, which has been designated diamagnetism. Now, indeed, that it is known that all bodies are affected by magnetism, though in two different ways—one class being attracted and the other repelled by the magnet—there seems little reason to doubt that the stability of the earth depends on the due balance between bodies in these opposite states. M. Plücker* observes, that when a body is formed of several elements merely combined together mechanically, its magnetism is the resultant or sum of the individual magnetisms of all the elements—a sum in which diamagnetism is represented as negative; and it may, therefore, be readily understood how much the magnetic condition may vary in sedimentary deposits, and what great disturbance of the magnetic equilibrium may be effected by the removal of detritic matter from one part of the earth, and its deposition and consolidation in another. The effects also of heat are very striking in modifying the magnetic force, the diminution being rapid from 32° to 500° of Fahrenheit, and then very slow, and still more sudden in diamagnetism, as the limit of rapid change is about 450° of Fahrenheit. Changes of temperature, therefore, may, in like manner, produce great disturbance in the magnetic equilibrium of bodies. M. Plücker's observations on the action of magnetism in the formation of crystals, and on the indication of terrestrial magnetism by crystals, are more especially deserving of attention. Having ascertained, by experiments on cyanite, augite, and oxide of tin, that the crystals of those minerals were under

* Sur le Magnetisme et Diamagnetisme; Annales de Chimie. June, 1850.

the magnetic influence of the earth, and that the polarity manifested was in direction co-incident with the mean line of the optical axis, he naturally inferred that a magnetic force might have been exercised in the formation of the crystals, or that the same force which exercises a directing power over the crystal when formed, may have also acted on the molecules during the process of aggregation, and caused them to take that position with respect to the poles as would correspond to that which the formed crystal would take when freely suspended. In this manner when melted bismuth is allowed to cool between the poles of a magnet, the particles assume such a position as to manifest distinct polarity, the principal plane of cleavage being perpendicular to the line connecting the poles. M. Plücker, therefore, asks, as a resulting question—"Has terrestrial magnetism had any influence on the formation of those crystalline masses which occur in the bosom of the earth?" and in replying to it, it is scarcely necessary to do more than to point to the great phenomena of stratification and of cleavage, as they are displayed in the crystalline stratified rocks. But whilst we are disposed to adopt electric and magnetic forces as great ultimate causes of modification and disturbance in the earth's crust, it would be neither prudent nor philosophic to exclude other causes when known to produce effects analogous to those we observe in nature. The sudden combination of oxygen, chlorine, and iodine with the metallic bases of the alkalis, is one of these, and though now unpopular ought not to be entirely rejected. When, indeed, the great quantity of chloride of sodium which exists in the sea and in salt-bearing deposits is considered, it does seem more than probable that much of it has been formed by such direct combination, attended by the evolution of much heat, and consequent physical disturbance. This idea is further supported by the very general diffusion of iodine in combination with potassium, both in fresh and sea water, and in fresh water and marine plants, as it is only natural to consider that the present condition of the sea is only a great final result, the formation of the salts it contains having been original, and consequent on the sudden combination of their elements.

But there is another theory which has obtained almost general

support, namely, the force exercised by the crust of the earth in its gradual contraction or cooling upon the liquid nucleus below it. It is on this theory assumed that the earth has been in an igneous fluid state; but there are two modes of considering its present state. In the one a consolidated crust is supposed to rest on a liquid nucleus; in the other, as advocated by M. Constant Prevost, cooling is supposed to have commenced at the centre, and the result to have been a solid nucleus separated from the congelated crust by an igneous liquid annulus. The congelated crust on contracting compresses the liquid matter below it, until the cohesive force of the crust yields to the pressure, and it gives way or cracks, when the liquid matter below is forced up, whilst the jar or vibration in the rending of the strata produces an earthquake or earth-wave. M. Prevost, in his fourth and fifth propositions, expresses distinctly this idea:—"At the same time that incandescent fluid matter, penetrating the cracks formed in the primitive crust by its contraction, has been either lodged in its interior, or poured out irregularly on its surface, and there on cooling become solid, detritic matter held in solution by the water or atmosphere has been precipitated, and formed stratified deposits, which have become consolidated by pressure, desiccation, and crystallization, giving rise to two classes of effects—the one ascribed to an internal plutonic or igneous agency; the other to a neptunian or aqueous agency—which either alternately or simultaneously have concurred in the formation, the dislocation, and degradation of the soil, just as volcanoes on the one hand, and the sea on the other, now synchronously and incessantly modify the state of the earth's surface. The undulations, foldings, fractures, depressions, and elevations, which both stratified and massive rocks have experienced—the shocks and dislocations consequent on earthquakes—the identity of composition of the substances poured out by volcanoes at all parts of the globe—cannot be explained with the same ease on any other theory than that which admits that the external crust or envelope of the earth rests on a zone of matter still soft and probably incandescent, whence have proceeded, at successive epochs, granites, porphyries, trachytes, basalts, and lavas."* M. Faye, in

* Comptes Rendus. September, 1850.

a letter to M. Constant Prevost, which was read before the French Academy, admits most fully the philosophical character of the fundamental theorems of M. Prevost, whilst he endeavours to remove the difficulty which the latter felt in regard to the formation of a crust on the earth. M. Prevost recognises the existence of the crust, though he appears to doubt the possibility of its formation on the surface of a fluid body, which he conceives would be so frequently disturbed by tides, as to prevent any steady settlement or continuity of a crust. He therefore infers that the earth cooled from the centre outwards, as would be the case in a perfect fluid; but this M. Faye does not admit, as there is no experience of the effect of tides on a viscous fluid such as the molten earth must have been when on the point of solidifying: nor, indeed, has their amount or character under such circumstances been investigated. M. Faye also observes, that the tidal wave does not prevent the formation of ice on tidal rivers, although the ice rises and falls with the tide, and that the density of the beds constituting the crust of the earth being less than the mean density, a considerable increase of density by contraction might be possible, without permitting any portion of the upper beds to sink and descend into the liquid portion below.*

This observation of M. Faye, respecting the coating of water by ice, leads me, from its analogical bearing, to close my remarks on this important subject by a reference to the theory of the Messrs. Rogers of Philadelphia. These eminent geologists have ascribed the phenomena of earthquakes and the contortions of strata to the movement of a wave on the liquid nucleus of the earth. It appears to me that this theory has been misunderstood, as I do not conceive, with Mr. Mallet, that they intended to represent the foldings of strata as actually waves of the solid crust, but merely as results of the compressing action of the semi-fluid wave moving under it. If, indeed, on contraction the solid crust was fractured, and by the consequent reaction the surface of the fluid nucleus was put into motion, the effect of the passing wave would be in proportion to the compressibility of the substances on which it acted, which as they yielded would be compressed and folded, as by any other lateral force, whilst from

* Comptes Rendus. October, 1850.

their imperfect elasticity they would retain nearly the position and form they had been forced to assume.

What has been here said will, it is hoped, be a useful commentary on a still obscure though deeply interesting portion of geological science; but in respect to the other great phenomena connected with those internal forces by which, in part at least, the disturbances and contortions of strata have been effected, it has always appeared to me that we must trace them up to their very cradle, in order to understand them clearly, and, therefore, that they can only be fully illustrated by a correct analysis of rocks. It is not enough to talk of metamorphic change, or to assume that a change such as that of a limestone into an essentially quartzose rock is possible, without previously appealing to the results of careful chemical inquiry. Without such chemical evidence the possibility of any change which implies an elementary change ought not to be admitted. Whilst the matter of rocks remains in a loose state, it is possible that both a separation and an arrangement of particles may take place within it; and that silica, alumina, and other elements may be thrown into definite positions; but when a rock has assumed a solid and even crystalline constitution such changes should be received only with great caution, and after rigorous examination.

The analysis by the Rev. Mr. Galbraith of some remarkable nodules, which I have described as occurring in the contorted schists of Whiddy Island, is a useful example, as the external aspect of the nodules is more like that of trap than of highly calcareous rocks. In this case there has been, under metamorphic action, a re-arrangement of the molecules, accompanied by a change of physical character, but without a removal of the principal original elements. Mr. Galbraith's analysis gives:—

Carbonate of Lime, ...	86·30
Carbonate of Magnesia, . . .	1·04
Carbonate of Manganese, . . .	3·44
Silex, ...	8·21
Water and loss, ...	1·01
	100·00

with traces of iron and alumina, the specific gravity being 2·709. To the presence of silex and manganese must be ascribed the peculiar trap-like appearance of these lenticular masses, which, doubtless, existed in the original strata as ordinary calcareous nodules. It is on account of this evident necessity to elucidate geological phenomena by the direct appeal to the chemist's crucible, that I value the continued exertions of M. Delesse. Of his various recent analyses of rocks, and what may be called rock minerals, such as euphotide, diallage, diorite, &c., I think it specially necessary to point your attention to that of protogyne or talc granite. Three different specimens from separate localities were examined, namely—1. The summit of Mont Blanc; 2. One of the Needles of the Mer-de-Glace; 3. From the Aiguille-du-Dru, which differed materially from the other two, having a gneisose structure and a density of 2·72. The results were as follow:—

	1st Specimen.	2nd Specimen.	3rd Specimen.
Silica, . . .	74·25	72·42	70·75
Alumina, . .	11·58	14·53	—
Oxide of Iron, .	2·41		
Oxide of Manganese,	traces,	traces.	—
Lime, . . .	1·08	1·03	1·08
Magnesia, Potash, and Soda, . . .	10·01	—	—
Water, . . .	0·67	—	0·71
	10·000		

He observes, that in the numerous varieties there are two distinct types: a granitic or highly crystalline granite, such as No. 1, which lies nearest to the axis of the chain, and contains mica, with little talc; and a schistose, which contains much talc; and, in like manner, that these differences are characterised by variations in quantity of silica, which increases on approaching the centre of the chain—a fact which certainly strongly supports the idea that all these rocks are metamorphic. This relation of the characters of the rock to the quantity of silica is also observable in the Vosges, excepting where the upper or outer portion of the rock is in contact with a sandstone—another remarkable evidence

of the probability of metamorphic action, and of the mode of its operation.

The quantity of water in these rocks is remarkably small, and in the more granitic varieties the magnesia, as a silicate, is small in amount, and appears with the silicate of iron to form the colouring matter; protogyne is then a granitic rock, and differs little from some common granites, except that it contains one or two per cent. of oxide of iron and magnesia. Its principal elements are quartz, two felspars—one of which is orthose, the other oligoclase—a mica of two axes, rich in iron, and a variety of talc. It differs from granites of two felspars by the composition of its mica and the presence of talc, for although this mineral is occasionally or accidentally found in granite, it is in protogyne an essential element, extending to nearly the whole formation, and being developed in large quantity. The Pegmatite of the Vosges is actually composed of three minerals—quartz, a felspar of the orthose form, and a silvery mica in which potash, soda, and magnesia are all present, and generally accompanied by tourmaline. The analyses of M. Delesse* are as follow:—

FELSPAR.	
Silica, . .	63·92
Alumina and Oxide of Iron,	20·05
Oxide of Manganese, . .	0·30
Magnesia, .	0·60
Lime, . .	0·75
Potash, . .	10·41
Soda, . .	3·10
Loss, . .	0·41
	99·54

MICA.	
Silica, . .	46·23
Alumina, .	33·03
Per-Oxide of Iron,	3·48
Manganese, .	traces
Magnesia, .	2·10
Lime, . .	traces
Potash, . .	8·87
Soda, . .	1·45
Water and Fluoride of Silicium	4·12
	99·28

It will be observed that when to the proportion of silica contained in these minerals be added that of the quartz, which is the most essential constituent, a rock very rich in silica will be

* Annales de Chimie. Jan., 1850.

the result; and this fact should be kept in view when comparing plutonic with truly volcanic rocks, and endeavouring to determine the limits of volcanic action.

The diorite of Port-Jean (Vosges), which appears at Port-Jean, near St. Maurice, in the Vosges, is thus described by M. Delesse.* Hornblende abounds in it, of the variety called actinote; it is very fibrous, and cleaves at an angle of 124 degrees. Its density is 3·059. The felspar is in lamellar crystals, is of a greenish white colour, a greasy lustre, and difficult cleavage. It gives to the rock sometimes a granitoid and sometimes an orbicular structure. It melts more easily than the hornblende. Analysis gives the following composition of the two minerals:—

	HORNBLENDE.	FELSPAR.
Silica,	50·04	58·05
Alumina,	8·95	28·66
Oxide of Chrome,	0·24	—
Prot. Oxide of Iron,	9·59	0·90
Prot. Oxide of Manganese,	0·20	traces
Lime,	11·48	6·37
Magnesia,	18·02	1·51
Soda,	0·81	4·12
Potash,	0·08	2·80
Loss by ignition,	0·59	2·40
	100·00	99·81

And as the chemical composition of the rock itself depends especially upon the proportions of hornblende and felspar which it contains, the analyses of these minerals may be considered the two limits between which the composition of the rock varies. The felspar in composition differs little from that of the Belfahy melaphyr, and is a variety of labradorite, so that in this case labradorite is associated with hornblende, just as it ordinarily is with augite, diallage, and hyperstene—the connexion with igneous rocks being preserved by the felspathic element, and not by the

* Comptes Rendus. 18th February, 1850.

hornblendic. Here also, as in most felspathic rocks to which an igneous origin is ascribed, are present the combined oxides of iron and titanium, and iron pyrites disseminated through the mass; and there are also veins of epidote, quartz, and carbonate of lime. But besides the felspar and hornblende the diorite of Port-Jean contains a felspathic paste, which is not crystalline, is of a greenish colour, a little paler than that of the hornblende, and in composition closely approximates to felspar. This paste, after having been kept for some time in boiling water, slightly effervesces with muriatic acid, but not with acetic acid, and is therefore penetrated by a small quantity of a carbonate of iron and probably also of lime and magnesia. It almost entirely loses its colour by ebullition in muriatic acid, and consequently is not coloured by admixture with hornblende, but probably by either green earth or chlorite. This circumstance of a pervading paste, which preserves within it undecomposed carbonates, suggests a doubt whether the crystalline portion may not have been the result of metamorphic change, rather than of igneous fusion and eruption. Indeed in almost every class of massive rocks there are members which indicate a tendency or power, in erupted rocks, to develop in other rocks with which they are in contact, under pressure, an assimilation to their own characters, provided the necessary elements are present.

The euphotide of Odern,* which is essentially a felspar and diallage rock, also contains carbonates. The diallage closely resembles some varieties of hornblende, and the rock is penetrated by talc in minute radiating lamellœ. Quartz occurs in veins, and sometimes a little carbonate of lime. The euphotide is associated with serpentine, and occurs along the line of contact between the granite and transition slates. Doubtless these peculiarities are also referable to the contact of igneous with stratified rocks, and imply a partial metamorphic action and reaction between the two.

The variolite of the Durance† is a very remarkable rock, as it is composed of a felspathic paste with disseminated globules.

* Delesse; Comptes Rendus. 11th February, 1850.

† Delesse; Comptes Rendus. 10th June, 1850.

The density of the globules is 2·923, and that of the paste 2·896, or below that of basalts. The analyses are—

GLOBULES.		PASTE.	
Silica, . .	56·12	Silica, . .	52·79
Alumina, .	17·40	Alumina, . .	11·76
Oxide of Iron, .	7·79	Oxide of Chrome,	traces
Oxide of Chrome,	0·51	Prot. Ox. of Iron,	11.07
Manganese, .	traces	Prot. Ox. of Mang.	traces
Lime, . .	8·74	Lime, . .	5·90
Magnesia, .	3·41	Magnesia, .	9·01
Soda, . .	3·72	Soda, . .	3·07
Potash, . .	0·24	Potash, . .	1·16
Loss by ignition,	1·93	Loss by ignition,	4·38
	99·86		99·14

It is supposed probable that 2·03 of the above loss may be due to the expulsion of carbonic acid from some of the constituents. Both the globules and the paste are felspathic in composition; and the greater quantity of iron and magnesia in the paste is ascribed to the partial crystallization exhibited in the globules, as in all rocks those two bases are, as it were, rejected or thrown into the mass in the crystallization of felspar. The globular is, in fact, the lowest form of the porphyritic character.

The examination, by M. Delesse, of the serpentine of the Vosges is also highly interesting, as it establishes a specific identity between it and the serpentines of Saxony, and of the Harz, notwithstanding the absence of crystallization. The garnets which are abundant in the serpentine are much more rich in magnesia than the garnets of other rocks, such as mica, slate, &c., and are, therefore, analogous in composition to the serpentine itself. Serpentine is a rock intimately connected with igneous irruptions and metamorphic action. The red porphyry of the ancients has also been analyzed by M. Delesse.* It consists of a felspathic paste with imbedded crystals of felspar, with small crystals of black hornblende and grains of specular iron, quartz

* Annales de Chimie. September, 1850.

being only accidentally present in small quantity. The specific gravity is 2·763; and M. Delesse shows, on comparing it with the porphyry of Rennes, that the hardness of such rocks varies, as well as their densities, with the quantity of silica they contain—the hardness increasing, and the density decreasing—so that the quantity of silica may be estimated approximatively by the density. The specific gravity of the Rennes porphyry is only 2·623, and it contains 77·99 per cent. of silica, whilst the antique porphyry contains 64·00 only.

The development of magnesian garnets in the magnesian paste of the serpentine, and of crystals of felspar in the felspathic paste of the porphyry, seems a result of slow cooling from igneous fusion. Another paper of M. Delesse deserves especial notice, as illustrative of the scrutinizing manner in which he examines rocks, and searches out the secrets of their physical changes.* He had before pointed out the great difference in the magnetic powers of rocks, and had shown that the effect of fusion was sometimes to increase and sometimes to diminish it. In this paper he states, that in rocks of high magnetic power minerals rich in iron are spread through the paste, whilst the minerals found in veins and cavities are comparatively poor in or destitute of iron. Such is the case in serpentines, melaphyres, basalts, lavas, &c. In rocks, on the contrary, possessing only low magnetic power, the minerals of the paste and of the veins are nearly similar as regards their amount of iron, as is the case in hornblende rocks, greenstones, &c.; and again, in granites, syenites, and other granitoid rocks, there is generally no definite paste, and in all cases it has a very low magnetic power. Even here, however, the minerals rich in iron are associated together, such as the lamellœ of black mica, crystals of hornblende, and grains of magnetic iron. Such associations are the result of a general law, and are the more strongly characterised as the rocks have a higher magnetic power. If, then, in amygdaloids, in serpentine, or other rocks of a high magnetic power, the mass be penetrated by solutions containing iron or chrome which are magnetic, and by others containing silica, lime, magnesia, alu-

* Comptes Rendus. December, 1850.

silica, and alkalies, which are diagmagnetic, the magnetic paste will retain or attract the magnetic solutions, and there will be found minerals rich in chrome or iron, and particularly magnetic iron; whilst, at the same time, it will repel the diagmagnetic solutions into fissures or cavities, where will be formed veins or amygdaloid nodules of quartz, carbonate of lime, zeolites, hydro-silicates and hydrocarbonates of magnesia.

"Magnetic and diagmagnetic forces have, therefore, acted an important part in the separation and association of minerals, especially when the latter have been formed by infiltration; and though the forces may be weak, they act constantly on very small portions of matter in solution, which are then in the most favorable conditions for facilitating the effects of attraction and repulsion."

"Even in the hypothesis of an igneous origin for the minerals of rocks, the same explanation will be available, as the magnetic action will then be exercised on matter in a state of igneous fluidity." M. Delesse further observes, that the electric forces are small in comparison with the magnetic, as regards their mineral effects; but it is highly probable, as suggested by Mr. Mallet, that the electric forces have co-operated in the reduction of mineral masses to a necessary degree of fluidity, as experiments have not yet established a direct influence of magnetism on the cohesion of fluidity, but rather the contrary. See the paper by E. Brunner, jun., Poggendorff Annalen, 1850, No. 1.

Such inquiries as these lead the way to a due appreciation of the phenomena connected with the distribution and association both of minerals and metals. In addition, however, to the long-continued action of magnetic and electric forces, ordinary chemical action and reaction have materially assisted in such operations. M. Daubrée* has examined the question in reference to the remarkable association of tin ores with minerals containing fluoric and boracic acids, such as mica, topaz, tourmaline, axinite, &c., which are generally sparingly spread in nature; and has explained it by the action of a volatile fluoride or boride of tin on a silicious mineral, such as felspar. Examples of the result of such reaction are observable at Saint Austle, Cornwall, where the oxide of tin

* Comptes Rendus. April, 1850.

occupies the place or fills up the form of crystals of felspar, every stage of the process being observable in the various degrees of the change. Not being able to use fluorides, M. Daubrée has imitated the supposed natural process by using the volatile perchlorides of tin and of titanium, and obtained, when the vapour came in contact with steam, in porcelain tubes heated to a white heat, crystals of oxide of tin and of titanium or brookite, hydrochloric acid escaping with the decomposition. It was remarked that the point of the tube where the crystals formed was at 572° of Fahrenheit. The chloride of silicium produced in a similar manner crystals of quartz; and it will be readily understood that in the case of a fluoride or boride the fluoric or boracic acid would have combined with the silicium, and produced some one or other of the minerals which usually accompany the oxide of tin in nature. M. Senarmont,* after recapitulating the experiments of Mitscherlich, Berthier, and Ebelmen on the formation, in the dry way, of the fusible minerals which occur in eruptive, and the crystallization even of infusible substances—those of Gay Lussac and Daubrée on the decomposition of volatile chlorides by contact with steam, such as occurs in volcanoes—the precipitation of carbonate of lime in the form of arragonite by M. G. Rose—M. Haidingers' experiments on the formation of dolomite—and M. Becquerels on the effects of long-continued weak electric currents—observes, that even these were probably not the only forces which worked in the laboratory of nature, and that some of them were not always reconcilable with the association observed; for example, the constant union of diaspore and corundum seems inconsistent with the intervention of excessive heat and the ordinary reactions in the dry way. M. Senarmont, therefore, suggests that the actual form of a mineral deposit should be consulted in estimating the mode of its production; and he considers, from such examination, that it is highly probable that many metallic deposits were produced from solutions; and to support this view he explains, by experiment, the mode in which certain carbonates and sulphates may have been formed in the moist way.

Carbonate of magnesia had been formed, by M. Marignac, by

* Annales de Chimie. October, 1850.

the reaction of chloride of magnesium on carbonate of lime; and M. Senarmont obtained it by the double decomposition of neutral carbonate of soda and sulphate of magnesia. At 212° Fahrenheit, and below, if a solution of magnesia in carbonic acid be mixed with chloride of lime, and the quantity of chloride be more than equivalent to the quantity of magnesia in solution, carbonate of lime only is obtained, without a trace of magnesia; whilst at 302°, whether the chloride of lime be more or less than equivalent to the quantity of magnesia in solution, carbonate of magnesia is obtained with scarcely a trace of lime; and M. Senarmont imagines that the precipitation of a mixed carbonate of lime and magnesia, or dolomite, would have taken place at some intermediate temperature. M. Senarmont illustrates, in a similar manner, the formation of carbonate of iron, &c., and then investigates that of sulphurets. The latter, formed in the moist way by double decomposition, are nearly amorphous, and assume the metalloid colour and state only at the points of contact with the glass tube—a curious fact, which shows that their formation in nature must have been gradual and slow, or else that they had been subject to subsequent solution. The deposition of anhydrous oxide of iron of a red colour, so common in various formations, is illustrated by the action and reaction of a solution of perchloride of iron, carbonate of lime, and carbonate of soda, at temperatures varying from 310° to 392°. M. Senarmont having also pointed out that sulphate of lime is precipitated anhydrous from a highly heated fluid, and the varying solubilities of carbonate of soda and chloride of sodium at different temperatures, observes that many of those combinations of minerals which occur so frequently in nature may be thus explained: for example, that waters charged with chlorides of calcium, magnesium, and iron should mix, under certain conditions of temperature and pressure, with waters saturated with carbonate of soda, and containing more or less of sulphate of soda, and the result would be a deposit of magnesian limestones, anhydrites, red oxide of iron, and rock salt. If, then, the great natural solvent water convey the dissolved mineral matter through the mass of the earth, and the magnetic forces operate upon it in its passage, many of those peculiar assemblages which are so striking in the crust of the earth must be directed to distinct points of

deposition, whether in veins or in cavities; and thus we obtain another explanation of that phenomenon, so remarkable in metalliferous deposits.

Mr. Wm. Mallet read a paper on the auriferous district of Wicklow, and described, in detail, the various minerals associated together in the auriferous sand. Although, in part, these minerals had been before noticed, such a succinct description of them, and such accurate identifications, were most interesting and valuable. The association of gold with platinum and tin, and, in other districts, with tellurium, palladium, &c., is one of those mineralogical facts which, though closely connected with the operation of some of the elementary forces which have acted on the earth's crust, cannot be satisfactorily explained. In like manner the auriferous veins have, in all countries where they exist, been found either in plutonic or metamorphic rocks, and principally in the latter, which seem to be the natural or primary habitats of such metals, as well as of some others which are also abundant from probably secondary segregation or deposit in more recent strata; and it may be reasonably inferred that their introduction into the veins was due, in part, to the causes which induced metamorphic change in the rocks containing them, and which were probably in part magnetic.

The gold-bearing strata of Brazil are stated, in Mr. Henwood's memoir on the metalliferous or gold deposits of that country,* to consist of granite, talcose, and clay slates, and a granular rock of quartz and talc, called itacolumite. These are followed by the jacotinga, which is the principal auriferous rock, and is composed, for the most part, of specular iron ore and oxide of manganese, but sometimes contains talc, mica, and quartz. The gold is either disseminated through the rock and in the short unconnected strings and masses in and forming integral parts of the strata, or disposed in veins or in vein-like masses.

The gold of Brazil is sometimes alloyed with palladium, silver, and platinum; sometimes it is mixed with native copper, and sometimes with large quantities of tellurium. The sulphuret of bismuth has also been occasionally found. Crystallized gold is rare, and chiefly occurs in the beds of rivers. Iron ore of the richest

* Mr. John Henwood, F.R.S., F.G.S. Jamieson's Journal, Jan., 1851.

kind is inexhaustible in quantity. The author had never seen a cross-vein, though he was informed by an intelligent German engineer that wide granitic veins traverse the gold vein at Candonga. I have referred to this district as it illustrates the geological connexion of the gold of Wicklow; and in the cross granite veins we have an indication that the phenomena of metamorphic change, and the formation of metalliferous veins were probably closely connected with the protrusion of the rock in which they occur.

Mr. Mallet's analysis gives the proportions of Wicklow gold:—

Gold, ...	92·32
Silver, ...	6·17
Iron, ...	0·78
	99·27

Or neglecting the iron, 8½ atoms of gold, and 1 atom of silver.

The Californian gold yields, according to the analyses

	of T. Oswald,	of B. D. Henry,
Gold, . . .	90·97 . . .	90·01
Silver, . . .	9·03 . . .	9·01
Copper, . .	— . . .	0·86
	100·00	99·88

The Wicklow gold is, therefore, considerably richer than that of California, though resembling it in its constitution.

Of twenty-five minerals, including two varieties of garnet, associated with the gold, Mr. Mallet notices platinum, titanic iron, sulphuret of molybdenum, topaz, zircon, the small manganesian garnets and augite, as new to this locality; and directs especial attention to the great abundance of tinstone, both as seeming to point to the probable existence in the surrounding district of masses of this valuable ore, and as in itself promising to pay for its separation from the sand.

The great interest which has recently been attached to this valuable metal by the discovery of the rich deposits of California, requires some notice of its history, and will justify me in offering a few remarks on the practical bearing of this discovery. Gold,

precious as it is, occurs far more frequently than is usually believed. Mr. Robert Allan, in his Manual of Mineralogy, thus speaks of it:—"Gold is not an uncommon metal; that is to say, there is none, except iron, more universally disseminated, although often in such minute quantities that its presence can only be ascertained after pounding and washing. It occurs both in veins and beds, in nodules, plates, and small crystals, coating the cavities or interspersed in quartz, but more frequently in the sand of rivers, in valleys and plains into which it has been conveyed from the decomposition of auriferous rocks. This is particularly the case in Brazil, Mexico, and Peru, where it is sometimes met with in masses of several pounds weight. In Siberia, too, it occurs in a similar alluvium or sand, in the country eastward of the Ural mountains, where masses of eight, ten, or sixteen pounds have occasionally been discovered. In Transylvania a considerable quantity of gold is obtained from stream works, near Hermannstadt. In the Wicklow mountains of Ireland, and at Leadhills in Scotland, it occurs in alluvial soil, and in many districts of Germany it presents itself under similar circumstances. My father's collection contains a specimen of a light yellow colour, weighing nearly eight sovereigns, from the Breadalbane estate, near Glen Coich, in Perthshire. In some places, as at Vorospatak, near Abrudbanya, in Transylvania, the rock appears impregnated with small portions of gold, which occur crystallized and in slender plates disseminated through the mass. The mines of Hungary and Transylvania, Cremnitz, Schemnitz, Posing, Betza, Magurka, Nagyag, Offenbanya, and Boitza, are all worked for this metal, occasionally affording the most splendid specimens; and in Saltzburg, and thence along the chain of the Alps, as far as La Gardette, near Allemont, in Dauphiné, there are numerous other establishments of a similar description. The Russian and Siberian mines have also latterly afforded considerable quantities of gold; and to the United States it promises to be a mineral product of some importance."

Of its more general history M. Virlet (Coup Œd'il General et Statistique sur la Metallurgic) gives the following interesting summary:—

The discovery of gold, like that of iron, copper, lead, mercury,

tin, and silver, dates from the remotest antiquity. In the earlier ages the greater portion of gold was supplied by some provinces of India, and other countries in the south of Asia, to which the Phœnicians sent their caravans, in order to exchange for it their manufactures; and it appears certain that this maritime people traded for gold with the barbarous natives of the southern coast of Africa, as they did for precious stones with the natives of Ceylon. In Lydia, Mount Tmolus and the Pactolus, a river so celebrated by the poets, supplied a considerable quantity to Greece, where it was used in the statues of the gods, and in decorating the temples." M. Aug. Perdonnet and M. Virlet think it probable that, in these remote epochs, the practice, still in use, was adopted of placing the skins of sheep in the course of an auriferous stream, by which the scales and fragments of gold carried along by the current were intercepted and secured; and that the allegorical fable of the Golden Fleece originated in this custom. Egypt furnished large quantities of gold, the Egyptians, according to Herodotus, overturning mountains in their search for the metal. From the mines of the chain of mountains which separates Thrace from Macedonia, Philip king of Macedon, obtained annually more than 1,000 talents of gold, or about £225,000 sterling, by the aid of which he succeeded in corrupting the Greeks, and reducing them to subjugation, thereby preparing the way for the conquests of his son, Alexander the Great. (It is, at least, gratifying to think that the treasures in this metal now flowing into the social current will be used for great commercial rather than military triumphs, and be made conducive to the advancement of civilization.) About this epoch the Phœnicians having seized on the temple of Delphos, carried off the accumulated gold which had resulted from the offerings of the kings of Lydia at the shrine of Apollo, and the quantity, therefore, of the metal so increased in exchange, as to rise to a proportion of one to ten as compared to silver instead of one to thirteen, as had been its previous proportion. In Europe (Spain and Transylvania) gold was also obtained from a remote epoch.

The rarity of gold, combined with its ductility, its malleability, and the ease with which, in consequence, it can be worked, caused it be selected, with silver and copper, as the best represen-

lative of wealth—that is, of the capital or accumulated results of labour of all nations. Such a system naturally replaced the cumbrous exchanges in kind, which could only suit the rudest state of society; and though iron has also, with other substances, been used as a means of exchange, these three metals (to which may now be added, as an experiment, platinum) have become the money or representative of value of all civilised nations.

The auriferous sands of Brazil extend over a large space, and gold is abundantly found in them, mixed with platinum, the diamond, &c. In a similar manner, it is from such sands that most of the gold of Chili, Columbia, New Grenada, Mexico, Peru, the United States, and Hungary, Transylvania, Siberia, and the Oural chain, &c., is obtained; and also probably the gold of southern Asia found in the Indian Archipelago, that of Africa which occurs principally in Kordofan, and that obtained between Darfour and Abyssinia, in the neighbourhood of Bambouck, and at the foot of the mountains which give birth to the Nile, the Senegal, and the Gambia.

The mines of greatest importance in Europe are those of Hungary and Transylvania, the Russian mines being in Asia, in the chains of the Caucasus, the Altai, and the Oural. Thibet, which produced gold in the earliest ages of the world—as, according to Heeren, the Phœnicians traded for it there as well as in several regions of India—still continues to export to China and Bengal large quantities, as well as diamonds, pearls, copper, cinnibar, lead, iron, white lead, &c., for which they receive in exchange, mercury, porcelain, gold and silver stuffs, coined money, &c. Nepaul alone receives from Thibet about £210,000 worth of gold every year, the greatest portion of which is swallowed up in ornaments both of women and men. In British India gold has been found both in the beds of rivers and in the superficial alluvia in sufficient abundance to be worked; and the gold "diggings" of Calcutta have been long known, and are now subjected to proper inspection and regulation. The auriferous soil of India is, however, very poor as compared to the sands of Africa, yielding only about $\frac{1}{36}$ of the quantity of gold for the same weight of alluvial matter. The gold mines of Spain, though of great antiquity, have, like those of France, ceased to be of any

importance, though many European rivers, like the Pactolus of the ancients, produce auriferous sands, which lead occasionally to lucrative "diggings" or explorations. Amongst these rivers are the Rhine, the sands of which contain also a small quantity of platinum, the Rhone, the Hérault, the Garonne, and many others, including some of the rivers of Germany, Spain, continental Greece, Macedonia, and Thrace.

In the United States of America the exploration for gold has, independently of California, greatly advanced since 1824, when it supplied to the federal mint only about £1,095 worth of gold, whereas in 1837 it yielded about £195,850 worth. The states which yield the gold are North Carolina, which produces about half the quantity obtained, Maryland, Virginia, Georgia, Tennessee, and Alabama—states which form the south-west of the American Union; and it is supposed that the production is about double the quantity actually coined at the mint. According to M. Eschwége, the gold extracted in Chili doubled in quantity from 1752 to 1761, when it amounted in value to about £1,682,900 sterling—a rate of production, however, which it has long since ceased to maintain, having probably, in common with the other South American mines, diminished to at most one-half. It is, then, at a time when the returns of all the old existing gold mines, excepting those of Russia, have fallen to a very low ebb, that California has been unveiled to the speculatist, and beckoned to its rich bosom thousands of the adventurous youths of both Europe and America, there to seek the coveted gold.

To form a just idea of the effect which this new source of gold will have on the interests of society, it is necessary to inquire into the absolute products of the older sources of supply, and to ascertain their relation to the wants of society.

Mr. Henwood states that sixty-three millions' worth of gold had been extracted from the mines of Brazil, which were first known to the Portuguese in 1695. To the end of 1846, the Russian gold washings had yielded about twenty millions. Sir R. I. Murchison considered the returns from California to be about one and a-half million per annum; and the latest Russian accounts show a production of more than three millions annually, being, as well as the Californian mines, on the increase. The coinage at

the United States' mint in Philadelphia shows a deposit, in 1850, of

31,500,000	dollars' worth	from California,
1,650,000	"	from other places,
33,150,000		

So that California furnished to the Philadelphia mint, in 1850, £6,562,500 of gold—a quantity which probably exceeds that furnished from the rest of the world, and also that furnished by all South America in any one year.*

The money capital of Europe alone has been estimated at about £214,791,667. If, therefore, California continued to produce at the extraordinary rate of 1850, it would double the present capital of Europe in about thirty-five years; but there is little reason, from the experience of former gold-mining districts, to anticipate a similarly continued production. Let it also be remembered that population increases almost in the same ratio, and that the wants, therefore, of the commercial world almost keep pace with the Californian supply.

There is also an important deduction to be made, namely, the loss by wear in circulation, accidents, &c., which has been estimated at about three-fourths per cent., or on the money capital stated above £1,610,937 annually; and if the money capital of America were added, the loss could not be less than £1,800,000; but to this should be also added the quantity of the precious metals used in ornaments, &c., which has been estimated at about £6,250,000, and it will then appear that the annual consumption amounts to about £8,000,000.

As the supply of silver has diminished materially, we may therefore, as yet, consider this new source of supply in gold as fortunately coming in to relieve a growing scarcity of the precious metals, although it must ultimately, if continued, disturb the relation which now subsists between the money values of silver and gold.

I trust when the great importance of the subject is considered, as well as the vast social result which has already followed from the discovery of Californian gold, you will excuse me for thus placing it before you in detail. A new State has now been added to the American Union, and that region which, only a few months since, was one of disorder, is now ruled with equity and decision,

*Hampshire Telegraph. January 25, 1851.

and the returns of labour are insured by a proper distribution of the land to be searched.

The mode of distribution of some minerals may be illustrated by the occurrence in sea water of silver, copper, lead, and of silver in plants and organic structures. It may be reasonably supposed that just in proportion as a metal is more easily acted upon by those chemical solvents which are spread through nature, it will be conveyed from one division to another of the mineral kingdom. It is, indeed, with the mineral as with the organic fossil, that its distribution from the original place of its first appearance will be advanced by the facilities of dispersion afforded to it. Silver is an illustration of this principle, as it is one of the elements most diffused amongst metallic minerals. Messrs. Malaguti, Durocher and Sarzeaud, have been led, from a consideration of this diffusion, as well as from the ease with which silver combines with chlorine, even in contact with salt water, and its chloride dissolves in other chlorides, especially chloride of sodium, and the powerful action of sea water on its sulphuret, to seek for this metal in sea water; for, as these authors observe, if the sulphurets of lead, iron, zinc, and copper, with which sulphuret of silver is so often associated, are all acted upon by sea water, and their resulting chlorides are all soluble in that water, how can it be doubted that the metals themselves must be present in that menstruum which washes so many different strata, and which holds in solution more than one-third of the known elementary substances.*

Following up the search founded on these principles, the authors succeeded in discovering silver in the salt procured directly from the water itself, and copper and lead from fuci which had extracted them from the water, but failed in obtaining zinc: iron had, of course, long been known as a constituent of sea water.

The mean of thirteen experiments gave half a milligramme of silver for 50 litres of sea water, so that 100 litres would have yielded one milligramme; and if we speak approximatively, and call the litres kilogrammes (one litre of sea water weighing more than one kilogramme) the proportion of silver is $\frac{1}{100,000,000}$; that is, one myriametre cube of sea water contains 1000 kilogrammes of silver, a quantity below the truth, as much of it must

* Annales de Chimie. February, 1850.

have escaped calculation from the difficulties of determination. In English measures this would amount to 2,400lbs. in about 216 cubic miles—a quantity small, though amply sufficient to establish the fact, which the author had also done by the ordinary reaction of sulphureted hydrogen.

The research was now extended to marine plants, the power of which to condense and retain within their tissues the elements of the medium in which they vegetate, had been so fully established in respect to iodine and many other mineral substances.

From St. Malo the authors obtained a mass of sea weeds, from which they extracted

Fucus Canaliculatus,
„ Vesiculosus,
„ Serratus,
„ Ceramoides,
„ Nodosus,
Ulva Compressus.

These were dried and reduced to ashes with the utmost care, and by preliminary experiments it was ascertained that they contained of soluble and insoluble substances the following proportions:—

	Soluble.	Insoluble.
Fucus Canaliculatus,	75	25
„ Vesiculosus,	53	47
„ Serratus,	41	59
„ Ceramoides,	35	65
„ Nodosus,	62	38
Ulva Compressus,	41	59

The experiments were now made in the dry way, and the result of six analyses were as follows:—

1.	Ashes of Fucus Serratus,	100 grammes,
	Button of Silver,	0·001 „
2.	Ashes of Fucus Ceramoides,	100 „
	Button of Silver,	0·001 „
3.	Ashes of Fucus Nodosus,	100 „
	Button of Silver,	imponderable

4, 5. The Silver was also inappreciable by weight, and in 6 doubtful.

From these experiments it is evident that all the fuci experimented upon contained silver; and, setting aside those in which the quantity obtained from 100 grammes of ashes was inappreciable by weight, it is evident that the quantity is really very considerable, amounting in fucus serratus and fucus ceramoides to $\frac{1}{100,000}$ part of the weight of the ashes. In other words, one pound of silver would have been produced from 100,000lbs. of ashes; and when we compare this comparatively great quantity with the minute quantity contained in the sea water, how strikingly and beautifully analogous is the assimilation of the metal in this case to that of carbon in ordinary plants.

The authors then proceeded to the examination of land-plants, and, making their experiments on those plants not subjected to the action of manures, which might have introduced silver into their tissues, conclude generally the presence of silver in plants—a fact which is perfectly in accordance with the general diffusion of silver throughout nature, and its association with most metallic minerals. The waters of springs percolating through mineral masses dissolve more or less of their chlorides, sulphates, nitrates, and other soluble salts, which, reacting in their course on metallic minerals, carry away in solution more or less of them; and, though the quantity may not be appreciable when sought for in so dilute a solution as the water of springs or rivers, it becomes recognizable when condensed and accumulated in vegetables.

It is thus that whilst the great forces of nature—combining, doubtless, electricity and magnetism—have been probably the agents for separating from the earthy mass metallic substances, and collecting them in the veins of massive and metamorphic rocks, the chemical powers of matter have been called into action to remove the metals from their places of deposit, and to spread them over the surface of the earth; and when these powers fail, the ordinary atmospheric agencies supply their place, and, as in gold and its associate metals, the distribution is effected by mechanical attrition and fluviatile transport.

There is one objection to these results which the authors anticipate and answer; namely, that the presence of silver in the sea may be consequent on the operations of man; but to this it may be replied, that if the whole of the sea contains the propor-

tion determined by their experiments, the total quantity of silver would be 2,000,000 tons, a quantity probably exceeding all which has been extracted by man from the earth: and even to carry the experiments beyond the age of man, the authors examined some rock-salt from the mines of Lorraine, and obtained from three kilogrammes, or seven pounds, a distinct button of silver. Whilst, however, this salt resembles the salt of our present ocean in this respect, it differs from it materially in containing only traces of sulphate of magnesia, without the muriate of that base, and in not as yet having produced either iodine or bromine, a fact which ought not to be overlooked in speculations on the origin of such masses of rock-salt. In experimenting on coal, the authors failed to discover such a quantity of silver as could be considered independent of accidental causes; nor is this surprising, as the vegetable matter forming the coal was doubtless deposited under circumstances which facilitated the removal of any mineral matter with which it might have been impregnated. They were, doubtless, estuary and not marine deposits.

The proportion of lead in the ashes of sea-weeds, of which fucus serratus, nodosus, and ceramoides formed the greater part, was determined to be $\frac{18}{1,000,000}$ grammes, and in like manner the presence of copper was also determined. This remarkable fact, that these three metals—silver, copper, and lead—are present in sea-water, is the natural result of their great diffusion in nature, and the ease with which they are acted upon by water either actually salt, or which contains more or less of the chlorides of sodium, &c., such as is the case with the springs which circulate in the upper portions of the crust of the earth. If, then, the presence of silver, copper, and lead, has been demonstrated both in the ancient and in the present oceans, such results are entirely conformable to the laws of nature.

We may add, that the presence of gold in plants was also long since stated by Becker and Hunkel, but has not been confirmed by subsequent experiments. Silver was discovered by Messrs. Malaguti, &c., in the blood of an ox. Lead and copper have also been found in animal tissues, but are supposed to occur only accidentally; and even as regards iron, which is present in almost

all organic structures, and manganese which is frequently present; Messrs. A. Chevalier and E. Cottereau are of opinion that the quantities are so variable that they cannot be considered essential elements of organic tissues, but merely as the result of peculiar food and circumstances.*

It does not appear to me that the great importance, as a geological fact, of the general diffusion of the alkalinic chlorides, bromides, and iodides, has been sufficiently appreciated. The recent discovery, by M. Chatin, of iodine in running fresh water streams, in fresh water plants, and in coal or the relics of ancient vegetation, adds additional weight to it. The diffusion of combinations of borine is an analogous and equally interesting fact. That element, like fluorine, is comparatively rare in nature, and yet is widely diffused. Rammelsberg† has given accurate analyses of the mineral tourmaline, which contains both fluorine and boracic acid, from thirty different localities of the old and new world, in most of which the quantity of boracic acid varies from seven to nine per cent., whilst the mean result gives about two atoms of boracic acid to seven atoms of silicic acid. I will not follow the author through his interesting discussion of the variations in the acids and bases of the mineral, but merely state that he has been enabled to form five distinct groups, classed under the two following heads:—

A. Brown and black tourmalines, without lithia.
  1. Magnesia tourmaline.
  2. Magnesia and iron tourmaline.
  3. Iron tourmaline.
B. Blue, green, and red tourmalines, with lithia.
  4. Iron and manganese tourmalines, blue and green.
  5. Manganese tourmaline, red.

My object is to point especially to the presence of boracic acid (a substance which is known to be emitted from volcanoes, or volcanic vents, such as the vapour springs of Tuscany, described by Sir R. Murchison) in the mineral matter of so many parts of the

* Annales D'Hygienne Publique. July, 1849.
† Poggendorff. Annalen, 1850, Nos. 8, 9.

earth's crust so widely remote from each other, is a fact of high interest. The probable agency of the volatile chlorides, fluorides, and, we may say, borides, has been already discussed in explanation of the formation and association of minerals; and, in respect to the extraordinary diffusion of the compounds which are the results of their action on, and combination with, mineral matter, it seems impossible to deny that so general an effect must have had a commensurately extensive cause. Is it, then, impossible that such gaseous bodies may be imprisoned below the consolidated crust of the earth in a state of liquid condensation?

After having thus shown that minerals and metals are most important geological elements, I may for a moment dwell with gratification on the Catalogue of the Simple Minerals of Trinity College, so ably completed by your late President, my learned and respected friend, Dr. Apjohn.* This catalogue exhibits a praiseworthy desire on the part of the University to increase the mineral branch of its museum. In 1807 a descriptive catalogue, drawn up by the Rev. Walter Stephens, was edited by Dr. Whitley Stokes, an eminent member of the University, to whom the charge of the museum had then been committed, and the number of minerals described was 1,089. In 1818, Dr. Stokes, in conjunction with Dr. Thomas Taylor, a distinguished botanist, published a second catalogue, when the number of minerals described was 1,204. In the present catalogue the number described is 1,994, so that it has been necessarily a work of great labour. It would be out of place to examine minutely this catalogue on the present occasion, but when I consider the peculiar qualifications of its author, his extensive learning and his practical skill, I cannot but hope that he will make it the text-book for further inquiries into the deeper mysteries of the mineral kingdom. The form and properties of minerals are, in themselves, deserving of attention and study; but when we consider them as elements of the mineral mass of the earth, it is necessary that we should not merely divide the genera, such as the silicates, but also the species, such as felspar, hornblende, mica, tourmaline, &c., into distinctive groups, in order to

* Descriptive Catalogue of the Simple Minerals in the Systematic Collection of Trinity College, Dublin. 1850.

connect them with the rocks in which they are found, and to trace out the mode of their formation. Such is the course now pursued by eminent continental mineralogists, and there is no one here who could so well undertake the task as Dr. Apjohn. With him, then, we may hope and believe "that the growing taste for chemical and mineralogical studies within the University will be stimulated and extended by the ready access which the students have to its mineral collection, and that it will contribute to the cultivation of the natural sciences, an object in which the heads of the University have, for several years, manifested an especial interest;" an object, too, let me add, which fully deserves the enlightened support it receives from the University of Dublin, and from other similar institutions, as the study of the natural sciences cannot be pursued philosophically without obtaining glimpses of the formative causes which have operated under the control of a supreme intelligence in the production of such great effects.

From the contemplation of causes which act, as it were, unseen, we naturally turn to those which are more palpably manifested in their effects, and of these, water, as a physical agent, is one. In a short paper, which I read on the 10th April, 1850, I described some remarkable inequalities of the sea-bottom of the present Portsmouth harbour during the tertiary epoch, which I illustrated by the differences obtained in three Artesian borings at very short distances from each other. In the first, at the victualling yard near Gosport, the superficial clays and sands, and two great beds—the one 87 and the other 100 feet thick—of the London clay were passed through, when an abundant supply of water was obtained at 312 feet. In the second, at Block-house fort, one and a-quarter miles from the former, the upper eighty feet consisted of gravel similar to the shingle of the present beach, with occasional sand and silt, and a small bed of oysters, which was followed by the London clay, divided into three beds by sand, in the one case yielding bad water, in the other no water, as if it were entirely circumscribed by clay; at 310 feet good water was obtained in a bed of clean sand twenty-four feet thick. In the third well, undertaken in one of the bastions at Portsea, distant two and a-half miles from the Clarence Yard well, and with it, on a line parallel to the chalk escarpment of Portsdown, there was only a very slight superficial

covering when the London clay appeared, and continuing for the depth of 500 feet, was, with the exception of a few inches of intervening hard sand without water, followed by the plastic clay, which continued as one uniform mass for more than one hundred feet more, or to the depth of 610 feet, when the borings entered the chalk, and water was obtained, which rose to within three feet of the surface. Making every allowance for disturbance of the underlying rocks by elevation, I must consider these extraordinary inequalities as principally due to the unequal wear, at successive epochs, of the ancient sea-bottom, and the irregular distribution of mud or silt upon it.

Mr. James M'Adam, in his papers of the 8th May and 12th June, has given many curious details which link together the pleistocene strata with the post-tertiary detritus gravel or drift. It is thus that on the County Down side of the Lagan, near Knock, a bed of clay occurs, which overlies the variegated marl, and is covered by a bed of gravel and sand. In this clay, at an elevation of 150 feet, occur specimens of nucula oblonga, establishing, with its other contents, an identity with the clay found on the Antrim side of the bay, at an elevation of one hundred feet, and with the clay described by me in my Report on the County of Derry, as occurring inland, at various elevations exceeding those here stated, along an ancient chalk escarpment. But the sand and silt, on which the greater part of the town of Belfast is built, contains also the nucula oblonga; and as there can be little doubt that this ancient mud-bank extends continuously with the more recent deposits into the Lough, there is a remarkable blending together of two deposits, distinct as to age. Mr. M'Adam describes the gravel beds or ridges which border the Lagan, and continue as the boundary of the Lough on the Down side, being replaced on the opposite side by a clay bank; and he considers "that the entire valley of the Lagan, along with the Belfast Lough, has been filled with gravel and clay, and covered with water, comparatively shallow, which, gradually descending in level, has left its marks behind in the appearances described." Mr. M'Adam ascribes the depression of the water, which must have once covered these gravel ridges and mud banks, merely to the wear of channels by the water, and its gradual sinking or letting out, and does not think any catas-

trophe or elevating agency necessary to account for it. He quotes, in support of this opinion, the theory of M. Streffleur, who imagines that currents produced by the rotation of the earth wear into the sea-bottom, and gradually depress it, so as to drop, as it were, down the water—a general and shallow sea being thus changed into partial, narrow, and deep seas. Without, however, in any way questioning the changes which are doubtless effected on the sea-bottoms through the agency of currents, some of which tend to depress it, and some, by the addition of drift, to elevate it—and further, without doubting that many peculiarities and changes in gravel and clay deposits may be purely hydraulic phenomena—I cannot admit that there is sufficient evidence to deduce a fall of the mean level of the ocean independent of disturbances of the earth's crust; and I will but point to the great chain of the Andes, a vast ridge of comparatively recent volcanic matter, or matter of eruption, and which is transverse to the direction of currents of rotation, to show that elevations must co-operate with depressions in producing great general results of change of level. M. Constant Prevost has, indeed, objected to the term elevation, as apparently implying an unbalanced protrusion of matter; but, of course, this is not the actual meaning of the term, as there is, doubtless, a corresponding quantity of matter depressed. Mr. M'Adam enriches his interesting paper by a detailed catalogue of shells found in the silt and sand, and also partially in some of the gravel. His list contains seventy-one species.

In my communication on Bantry Bay I brought under your notice one of those examples of the scratching of rocks, by the passage over them of sharp detritic matter, the surface having been previously worn smooth and partially polished by a similar action. The example, which I described from my own personal observation, was taken from one of those bluff clay banks so common in Bantry Bay the interior portion of which—meaning that part within Whiddy Island—appears to have been formed by denudation of a comparatively recent date, or subsequent to the formation of post-tertiary deposits. The wear of this great mass of gravelly clay studded with boulders, or, in other words, of boulder-clay, is still continuing, and must continue, so long as any portion of it remains within reach of tidal action. As the

level of the water rises, the waves beat upon the base of the clay cliff, and gradually undermine it, until at length the top falls in, and for a time the base is protected by the fragments. When, however, they have been washed away the work of destruction is renewed, and slice after slice of the cliff or bank is thus removed, until, at length, the base retires beyond the action of the higher tides, and the cliff, exposed only to ordinary atmospheric agencies, finally crumbles into a slope fitted for the preservation of statical equilibrium. In the progress of this wear it is usual to find the boulders and larger gravel of the clay heaped up as water-worn shingle at the base of the cliff, the finer matter or clay having been washed away. It was at the base of a bluff headland of this boulder-clay, which is only exposed to the action of the waves in very high tides or in storms, and is, in part, protected by a bank of water-worn shingle, which had once been imbedded in it, that I observed a portion of the rock laid bare, which, far from exhibiting the jagged edges of the strata habitually exposed to the wear and tear of the waves, was smooth and rounded in its surface, and further marked by fine sharp scratches, varying in their parallelism according to the relative positions of the slopes of the rock and the consequent direction of the scratches. It further appeared to me that these scratches passed under the clay; and I therefore assumed, as probable, that they had been made by substances moving with or imbedded in the clay. It will be understood that I endeavoured merely to state a fact, and not to describe historically the phenomena with which that fact would be naturally connected. It is right, however, that I should now observe, that in my Geological Report on Tyrone and Londonderry, published in 1843, I have distinctly pointed out that the phenomena of drift are such as cannot be explained by any one movement of water, whether diluvial or fluviatile or marine, but are the results of actions often varied in their direction and amount, in a manner very similar to that which can be traced in more ancient deposits. In the illustrations to that work I have given examples both of contorted strata and of cross or false stratification in drift, and have contrasted them with similar appearances in secondary sandstone rocks. It is not the time to enter into an explanation of such phenomena further than to urge that they prove a long-

continued and regular mode of deposit, implying a sequence of strata. Nor do I see anything in their character which can, *a priori*, decide in any case whether they preceded or followed the deposition of boulder-clay. Local evidence has, however, proved that in some cases the boulder-clay preceded the stratified sands and gravel; but it is not impossible that, in other cases, marine currents may have swept over the surface of rocks, and hurried with them sand and shingle prior to the deposition of boulder-clay. If such were the fact the surface of a rock may have been smoothed and polished by the friction of the sand passing over it, and subsequently grooved and scratched by the more slow movement of glaciers or of boulder-clay.

I have now come to the point where I may fitly notice the paper or letter of a respected fellow-member, your former president, Mr. Robert Mallet, brought forward on the 11th December, in which he lays claim to priority in an explanation of the mode in which rocks have been grooved and scratched. Mr. Mallet states that, in company with Professor Oldham, he examined, in May, 1844, the cuttings of the Drogheda Railway made through the calpe, in the neighbourhood of Killester, and observed numerous scratches in the rock, and on the lower surfaces of boulders imbedded in the clay and gravel beds above it; that some of the scratches appeared to indicate that the superincumbent clay had been forced *en masse* up hill over inclined calpe beds; and that he concluded, from the evidence in general (and communicated his views on the subject to Professor Phillips and the Council of the Society, on the 5th June, 1844), that the scratches had been caused by the movement *en masse* of "the clay and gravel beds over the rock beneath, and that the scratches upon the latter, as well as those upon the large boulders reposing on the rock and imbedded in the clay, had been produced by their being carried over the rock along with the moving masses of clay and gravel." On the 12th Nov. 1845, Mr. Mallet read a paper on the subject to the Society, and then "enunciated the doctrine that the lateral movement of masses of mud, sand, and gravel, while in a wet and plastic state, either under the sea or upon land very recently elevated above it, had been the great agent not only in the almost universal scratchings observable upon the surface of the rocks of every part of the earth, but had been also the means of transport of the far larger proportion of the boulders and greater drift masses that cover the earth." Mr. Mallet showed the close similarity that, in his opinion, exists between the motions, internal and external, of a moving mass of mud or sand and gravel, or of vast landslips, and of those of glaciers; and, at the Cambridge meeting of the British Association, again brought forward his views, adopting the term "mud glaciers," as illustrative of this supposed similarity.

It is thus on these grounds that Mr. Mallet claims priority of discovery, and complains that many geologists have adopted his mode of explanation without acknowledging or referring to that priority; and it becomes necessary, therefore, that I should set before you so much of the history of this branch of geological science as will be necessary to understand and to decide on this claim.

It is scarcely necessary that I should here observe, that by early geologists, with some exceptions, the existence of gravel and sand was ascribed to diluvial causes, and that scratches or marks of friction were considered evidence of diluvial currents. In Catcott, for example, the transport of detritic matter by the diluvial stream is strongly urged, and the wear of the strata by diluvial waters. In like manner these effects were ascribed to the movements of water, when Hutton and his pupils Playfair and Sir John Hall, had advanced and illustrated the theories of elevation of mountain masses and marine currents. Mr. Greenough (1819), in his critical essays, observes—"These theories refuted, there remains, in explanation of the phenomena of boulder-stones, the theory which attributes their occurrence, like that of ordinary gravel, to the action of running water. The arguments in favour of that doctrine are, that boulder-stones are evidently not *in situ;* that they are, for the most part, traceable to the parent rock, which, however distant, is always at a higher level than themselves; that they often rest upon beds either secondary or alluvial; and, lastly, that the upper surface of rocks protected by soil is, in many cases, so furrowed as to resemble a wet road along which a number of heavy and irregular bodies have been dragged, those furrows generally agreeing, in parallelism, both with one another, and with the ridges and large features of the district."

Mr. Greenough, not considering the force of running water, either as exhibited in the torrents of rivers or in the sea, sufficiently great to account for such results, ascribes them to the deluge. Hutton had ascribed them to the tumultuous rush of water consequent on great debacles, the result of sudden elevations of mountain chains or masses.

Dr. M'Culloch, in his System of Geology (1831), observes in his chapter on Changes in the Disposition of the Sea and Land,

"But I must not omit one argument supposed to afford a strong evidence of such diluvial currents; namely, the scratches or marks of friction already noticed in rocks where water does not now flow. Many of the quoted instances occur in places where rivers have once run, under the changes already pointed out; while if the others confirm the former existence of currents that could not well have been rivers, they are not competent to prove such movements of water as I have here rejected (diluvial). I shall inquire further of them presently, as the probable *effects of heavy* alluvia transported by water under other causes," an idea which is similar, if not identical, with that of Mr. Mallet.

Again, in his descriptions of alluvia, Dr. M'Culloch has one section denominated "alluvia of descent." He says—"The necessity of revising the alluvia has caused me to give this name to those which are produced by a combination of gravity, aided by rain, with the ordinary disintegration of the summits of mountains. These occur in all declivities, and consist of clay and sand, with fragments often of great size, which, if generally angular, are sometimes slightly rounded, from partial attrition or decomposition. Their real origin is indicated by their position, by tracing the progress of the operation, and by the nature of the substances. Their depths vary according to circumstances, and they often descend so far as to occupy the valleys beneath." "As these appearances occur in very gentle declivities, as in Cumbray and Isla, or almost on level ground, as near Comrie, here is a demonstrated cause of even transportation which geology has overlooked. That even boulders may have been gradually moved in this manner to great distances from the parent rock, is abundantly obvious; and I may here say, once for all, that whatever volumes may have been bestowed on these travelled blocks, there is no reason for separating them from the several classes of alluvia to which they belong"—an idea again identical with that of Mr. Mallet. M. Dausse, in his Essay on the Chaine des Rousses (1834), describes the mountain gorge of Flumay, which is formed by the junction of the granitic and gneisose rocks of the great chain of the Rousses with the slate escarpment of Côte-Belle. This deep ravine narrows at its bottom almost to a line, and has there a steep descending slope. On the left and towards the head of the gorge,

the gneisóse beds, which are above, have been greatly dislocated, and have produced huge accumulations of debris at the bottom. On the right, "the very bowels, as it were, of the mountain de Côte-Belle are exhibited as the various beds crop out in the steep escarpment. Strangely, indeed, is this escarpment ravined and grooved, and notched by the projecting of its several beds, and shaped into rugged asperities and bold needles, which are incessantly giving way and falling to the bottom. It is here that we find torrents or 'coulées de débris,' which the rains and great thaws have the power of moving. In this passage, M. Dausse almost seems to have Mr. Mallet's illustrative image of a glacier in his mind, but he contents himself with merely stating that huge accumulations of debris are made to flow down the course of a steep ravine by the increased power of water consequent on heavy rains or sudden thaws.

Quotations of a similar character might be multiplied, as the first mode of explaining the polishing and grooving of rocks was naturally to ascribe them to the passage of drift—or, as it was then considered, or at least called, diluvial matter—over them.

D'Halloy (1831), in his Elements, states, that M. Brongniart had observed portions of the primordial rocks (granites, &c.) where the surface had been polished and grooved in the direction of the trainées of debris, as if it had been worn by the passage over it of the blocks composing them. These trainées in Scania and Smalande form longitudinal hills, which the Swedes call 'as,' or 'ose;' our Irish escars. M. D'Halloy classifies, from the observations of M. de Beaumont, the drift or diluvium thus:—"It apparently occurs in three different forms. In the bottoms of valleys it appears as terraces, separated by a longitudinal depression, in which, like a secondary valley, is the ordinary watercourse; in plains it is spread out in vast horizontal 'nappes,' or sheets; and in mountains and hills it occurs as erratic blocks. It cannot be said that it exhibits a true stratification, though its masses often exhibit a partial parallelism. M. De Beaumont considers it generally in unconformable stratification with the strata which it covers; and, it may be added, that excepting where secondary valleys have been worn in it, the tendency of drift has been to

fill up hollows and inequalities, and to reduce the surface of the earth to horizontality."

It will be observed that the proximate cause of the polishing and grooving rocks was naturally sought in the passage of drift over them, and that to explain the cause of the movement of that drift was the real difficulty. Fluviatile, marine, and diluvial currents have all, in turn, been called into action; and had our learned member, Mr. Mallet, given us a clear and satisfactory explanation of a new mode in which such large masses of drift might have been put into motion and spread over the surface of the earth, he would, indeed, have deserved our thanks. His reference to the movement of landslips does not appear to me such an explanation, as it involves a generalization similar in character, and certainly more defective than that of Agassiz, in respect to glaciers.

It was, indeed, principally to supply the defective cause of the motion of drift that Agassiz endeavoured to generalize the phenomena of glaciers, so as to make them consistent not only with the drift of mountain valleys, but also with the immense detritic coating of the level plains below them. The effect of his first exposition of the phenomena to British geologists, who were not, like those of the Continent, familiar with the writings of Hugi, Charpentier, and Venetz, was truly surprising; and many of the most distinguished, headed by Dr. Buckland, entered upon the search for glaciers with the utmost enthusiasm. Nor has the subject lost its interest even now, as almost every season produces new examples of former glacial action on the mountains, humble as they comparatively are, of the United Kingdom. Agassiz was not originally an advocate of the glacier theory, but, as he informs us, considered the explanation of drift and its effects by marine currents more simple and rational. Personal intercourse, however, with Charpentier soon brought him to concur in the opinions of that author, and he became their most zealous and successful expounder. In one respect, the advocate for glacial action has this great advantage, that he can appeal to nature for proofs of the transporting power of ice—whether on land, as exhibited in the glacier, or in water, as manifested in the iceberg, or in the icefloe; and the real question, therefore, is, whether that transport-

ing power is equivalent to the effects which have been produced. On this point we may freely admit, as had been done long before, that the transport of large erratics is best explained by referring them to icebergs or icefloes. In like manner, the grooving and polishing of rocks within mountain chains, and even the arrangement of mountain drift, may be fairly ascribed to glaciers; but a doubt may be reasonably expressed whether either or both of these actions can explain the arrangement of the more widely spread drift of plains; and we are forced to call into our aid marine currents, more especially tidal currents, of which we shall again speak in the sequel of these remarks. It is right, however, to inquire first into the peculiar relations of the glacier to the effects we are now studying. M. Agassiz states (Etudes sur les Glaciers, 1840, p. 184), "The bottom of the glacier does not always rest immediately on the rock or ground, but is usually separated by a bed of sand or mud, which, according to its thickness, contributes more or less to the formation of terminal moraines. This bed proceeds from the fragments of rocks which fall under the glacier, either through its numerous cracks or by its margins, and are triturated into minute particles by the grinding action of the glacier as it moves along its channel. When glaciers move over granitic rocks, this bed is composed of very fine, white, and very loose sand; when, on the contrary, the moraines, which supply the materials, have proceeded from calcareous or slaty rocks, the bed is dark and pasty. It is to the small gravel contained in this intermediate bed that the characteristic striæ of polished rocks must be ascribed. In the upper valleys, this bed is frozen and adherent to the ground, whilst in the lower it is thawed. Independently of this bed of sand or mud, it is not unusual to meet under the glaciers a bed, more or less considerable, of small rounded blocks, varying from the size of an ordinary pebble to a diameter of six inches or a foot. These rounded boulders, which have been evidently triturated and worn like the sand by the movement of the glacier, strongly resemble the gravel beds of what have been called diluvial deposits, and, were they not so clearly connected with the glacier action, would be ascribed to powerful torrents. These beds of pebbles vary considerably in different glaciers, and are specially well exhibited under the gla-

cier of the Trient, where it is manifest that they proceed from the detritus of the sides of the valley, and are renewed continually as the more ancient portion of the bed is pushed forward to the lower part of the valley—a fact which negatives the supposition that the glacier may have been formed on a tertiary deposit."

M. Agassiz also points out that fragments encased in the ice act as files or rasps upon the rock when the glacier is in actual contact with it—a mode of operation which has been reasoned upon, whilst the other, or that in which a mass of detritus is moved with and under the glacier, has almost escaped notice.

Agassiz indeed says—"We have seen that the bed of mud and gravel, which is intermediate between the glacier and the bottom of the valley, contains a quantity of small fragments of very hard siliceous rocks, and, being moved on by the mass of the glacier, act as so many diamonds on the rock below, scratching its surface, whilst the mud and ice polish it. If," he adds, "the striæ and grooves under existing glaciers had been laid bare, and thereby made as distinct as those of extinct glaciers are, the connexion between the striæ and the action of glaciers would have been long since admitted, and an explanation of the phenomena neither sought for in currents of water or of mud."

I shall quote no further from M. Agassiz, and I have dwelt so long on the subject merely because I consider it of high importance to determine the real mode of deposit of the various descriptions of drift; and though I have observed a disinclination in many geologists to dwell on this or other branches of physical geology, I cannot but feel that it must ever be a reproach to geology if it cannot succeed in unravelling the difficulties which still obscure our explanations of drift, an operation which has taken place almost at the moment of man's birth. My predecessor in your chair had also occasion to refer to this subject in his address; and with his observations I partially agree, partially disagree. I cannot agree with him when he considers M. Martin's argument defective, in illustrating the possibility of glacier action in the mountain near Loch Lomond, at an elevation of 2,400 feet, by the discovery of such action in the Alps, 2,468 feet above the bottom of the valley which contained it. There is evidently no analogy between the case he adduces, namely, that as one rock (protogine, for

example) occurs in one district, the statement of its occurrence in another might be thereby established. Doubtless were some strange and apparently anomalous rocky compound said to have been found in some particular district, our belief of the possibility of its existence would be aided by a knowledge that it had been found in some other similar district; and in this way the glacier phenomena of the Alps may reasonably be called in to illustrate those of the Scotch and other mountains. I do, however, agree with my learned predecessor—and I had long since expressed that opinion—that it is dangerous, nay unphilosophical, to view the phenomena of all "so-called drift deposits only in connexion with, and as illustrated by, the phenomena of Alpine glaciers." On a former occasion I stated, as Sir R. Murchison has also done, that the composition of our ancient conglomerates and sandstones is, from the absence of boulders, such as not to lead to a belief that even glacial or ice action had existence at the time of their deposit; and if this opinion be correct, accumulations of ancient drift in sand, gravel, and mud must have then taken place through the agencies of fluviatile and marine currents alone. But let me ask, has the recent removal of any of the secondary or tertiary strata from the rocks below them, either by quarrying or fluviatile action, laid bare surfaces worn in the manner which has been described? I have seen evidences thus displayed of the ordinary action of water, but I have not seen the polished or striated surfaces. Often, for example, may be seen on the sloping side of the beds, the surface of micaceous schist, when recently bared by the removal of superficial strata, still exhibiting the well-known ripple marks, but no transverse striæ or grooves. I throw out this observation in the hope that the absolute antiquity of such markings may be defined. Whilst, however, I cannot limit the phenomena of drift to any one glacial cause, I must admit and acknowledge the vast importance of the recent study of glacier action, as without the demonstration of the more extended existence of ancient glaciers it would be impossible to satisfy the mind that a truly glacial epoch had occurred in the earth's history. The establishment of the former extension of glaciers naturally proves the greater amount of general cold, and prepares us to admit the floating icebergs and icefloes, which are assuredly the most natural and

efficient means of transporting the huge erratic boulders which have been spread over our now dry land. Such phenomena are now exhibited by the icebergs of our own seas, which convey fragments of rock thousands of miles from their natural seat; and would it not be truly unphilosophical to deny the possibility of such agencies at more remote epochs, or to refuse the corroborative evidence which ancient glacier action adduces in its support. But whilst the glacier and the iceberg were performing their parts, the river and the seas were not idle: and thus the true explanation of drift must combine the actions of all. One of these, namely, the simple action of the tidal current, seems scarcely to have been noticed in reference to this subject, though it has, doubtless, co-operated materially in producing some of the results observed. Almost every bay on our coast may afford evidences of the accumulation of gravel and sand by tidal currents; and it is very curious to observe how the shingle, or marine gravel, is sometimes moved over a smooth surface of sand. Nor is this the only effect, as I was enabled to observe, to great advantage, the action of the moving gravel in producing grooves in more solid substances, as exhibited in the breakwater at Southsea Castle, near Portsmouth, which has been worn in the most remarkable manner in deep parallel grooves, so as to assume the appearance of the most complicated mouldings. I have no doubt that a similar grooving takes place in ordinary rocks when favorably situated as regards the tidal current; and I would, therefore, suggest to every observer of such phenomena the inquiry, whether the grooving, as regards its physical position, is most nearly in relation to the action of a land glacier or to that of tidal currents.

Nor must fluviatile action be overlooked, as its power is very great under fitting circumstances. For example, can it be doubted that such a river as the St. Lawrence must, both by its waters and by the masses of ice it bears along upon them, convey large quantities of detritic matter, and arrange that matter at the bottom of the lakes in a manner very similar to that observed in the drift of our plains and estuaries. Other evidences of fluviatile action in pot-holes, &c., as pointed out by that eminent American geologist, Professor Hitchcock, should not be overlooked. On solid rocks the action of rivers is small, but on

the softer secondary strata, and on drift, it is considerable. In these latter cases they are modifying agents, removing and readjusting ancient drift, so that it is to more ancient rivers, or more ancient causes generally, that we must ascribe the drift itself. In making our selection between these causes we must not forget that a mere present difference of level between the point observed and the bottom of the valley or the stream running in it, is not a sufficient reason for rejecting the evidence of glacier action, as subsequent elevation has, doubtless, raised up the whole. In the glacial period when, as it is presumed, this extension of glaciers occurred, it is highly probable that our mountains were less elevated, whilst the limit of eternal snows was brought nearly to the level of the ocean. If, then, I consider a glacier as a true motive power applied by nature to transport drift, I consider it only as one power among many. I look upon it also as auxiliary to other glacial agencies, as it is the carrier by which detritus is conveyed from the mountain top and valley, until it is confided to the iceberg or icefloe, to be floated away to other and distant regions; but even with these restricted views of the geological agency of ice, it is evident that our knowledge of the phenomena connected with it cannot be too much extended; and I am happy, therefore, to see that it continues an object of zealous research. The cause of glacier movement has been much disputed. Many philosophers, Saussure, &c., ascribed it to gravity alone, or to gravity assisted by the flow of water below, which acted like a liquid roller to the mass; but, prior to this suggested explanation, Scheuzer had, in his "Itinera Alpina," propounded a different theory, namely, the expansion of a mass of ice by the freezing of water which had filtrated into its capillary cracks. This theory had been forgotten, when it was revived by Charpentier, and adopted by Agassiz. According to Agassiz, the process of formation goes on thus: first, snow which, by absorption of rain and other water and freezing, is formed into a granular mass called nevé, or firn. As the process continues, the nevé approaches nearer to the character of ice, until at length, beginning at the bottom, it is completely converted into ice. In the upper portion of a valley, therefore, the ice of a glacier must be necessarily covered deeply with nevé or with snow; but as the glacier moves

downward the greater quantity of water absorbed by this covering reduces it more and more to ice, and it seems, at length, to emerge as a simple glacier from the regions of nevé and snow.

This theory was controverted by Professor James Forbes, who adopted, as the result of his own observations, another, namely that of semifluidity. In his last or sixteenth letter on glaciers,* Professor Forbes again notices the progressive movement of a remarkable stone called "La pierre platte," lying on the surface of the glacier de Léchaud. This had moved, between 27th June, 1842, and 12th July, 1850, 2,520 feet, of which it had travelled prior to 21st July, 1846, 1,212, leaving 1,308 feet for the last four. The mean annu al and daily motion being as follows:—

	1842-3	1843-4	1844-6	1846-50
Daily motion, in inches,	9·47	8·56	10·65	10·8f
Annual motion, in feet,	288·3	260·4	323·8	328·8

The movement of a large block near the centre of the Mer de Glace, from 1846 to 1850, was found to be 3,253 feet, the mean annual motion being 822·8 feet, and the daily 27·05. Professor Forbes now cites, in support of his theory of quasi-fluidity on glacier masses the experiments of M. Person, the French chemist, who states—"that ice does not pass abruptly from the solid to the fluid state; that it begins to soften at a temperature of 2° centigrade below its thawing point;" that, consequently, between 28° 4′ and 32° Fahrenheit, ice is actually passing through various degrees of plasticity within narrower limits, but in the same manner that wax, for example, softens before it melts. M. Person's words are—"Ice is, then, one of the bodies the fusion of which is most sudden, but, notwithstanding, that the passage from the solid to the liquid state is one by steps, and not abrupt." M. Person, as Professor Forbes states, obtains this result from the examination of the heat requisite to liquify ice at different temperatures, and not from its mechanical condition; and I, therefore, much doubt the validity of the conclusion deduced from it. In fact, it is very surprising that a direct reference should not have been made to the physical condition of ice—a reference so easy in our northern climates.

* Jamieson's Journal. January, 1851.

Is, for example, the ice formed on a frosty night in autumn and spring, and which still exists for some time after the temperature of the air has risen above 32°, in a plastic state? And, further, may not the peculiar relations to caloric, noticed by Person, be due to other causes connected with the physical condition of ice?

The researches of Hermann Schlagintweit,* on the Physical Geography of the Alps, and the extract given by him, in Poggendorf, of that part of his work which relates to glaciers, are most valuable documents in the examination of these questions.

Schlagintweit states that the ice of glaciers when exposed to the air falls into fragments or grains, which are loosely held together or locked by their projecting edges, the form of the grains being very remarkable, and strongly resembling the articulating portions of bones. Their size varies materially: in the upper portions of a glacier, or near the point where they emerge from the sea of nevé or firn, they are the smallest, seldom exceeding in volume $\frac{4}{10}$ inch cube. There are small hollow spaces between them, which are sometimes filled with air, sometimes with water. At points more distant from their origin the size of the grains, or elementary fragments, increases to two or three inches cube. It is to the grating or rubbing of the projecting portions of the articulating fragments that the peculiar noises of the moving glacier are due, resembling, in fact, the noises of a rusty hinge. The capillary cracks of the ice are ascribed to differences of temperature in the successive layers, or to the consequent differences of contraction, whereby the upper layers are split, as in the case of suddenly cooling metals or glass, into a network of capillary cracks. The greater the cold the more abundant the cracks, and the finer the network. It is to be remembered here that the expansion of ice is very great, being greater than that of zinc, tin, lead, silver, brass, iron, glass-rod, talc-spar, amounting to 0·0000375 for 1° cent., or, according to Struve, 0·000052.

The ice, therefore, of glaciers is composed of what may be called loosely articulated grains or fragments, mixed up with numerous air-bubbles or cavities, and divided by many capillary

* On the Physical Peculiarities of Ice, and their Connexion with the Phenomena of Glaciers. Poggendorf: July, 1850.

cracks. The frangibility of the ice is due to this condition, and it is to the ease with which, from this structure, the mass can move within itself that the power of moving over rough surfaces is derived; and it is due to this peculiar structure that ice assumes the character of a semi-fluid, or of a plastic mass. M. Schlagintweit also demonstrates the similarity of structure of ordinary water and glacier ice, excepting that the latter is peculiarly rich in air cavities, and is, consequently, more frangible. Ice, he concludes, exhibits, wherever we meet it, all the peculiarities of hard but brittle bodies.

In a short communication which I made to the British Association, at its Swansea meeting in 1848, and which has been published in "Annals of Philosophy," I pointed out that the ancient sands and gravels, which occur as sandstones and conglomerates in so many formations, exhibit no traces of the boulder phenomenon; and also, that no groovings or furrowings analogous to those which have been ascribed to glacial action have been discovered on the surface of rocks when merely laid bare by denudation. Every one is familiar with the ripple mark on slates, and all must have observed traces of ordinary wear by marine action, so that the absence of boulders and furrows must be ascribed to some great change giving rise to a new class of phenomena. I also pointed out, as Olbers had previously done, the absence of ærolites in the older rocks; and, though an example has been since discovered in the tertiary deposits, and it has been endeavoured to explain their absence from older strata on the supposition of rapid disintegration, I must still consider that such absence is due to some greater physical cause.

My friend, Mr. Henry Hennessey, allows me to quote the result of his paper read to the British Association at Edinburgh, in 1850, as bearing on this question. Mr. Hennessey first points out the comparative number of falling stars, fire-balls, and meteoric stones, which have been observed in the perihelion and aphelion portions of the earth's orbit, the former including the months from October to March, the latter the months from April to September; and cites the table given by Kaamtz, by which it appears that the number of the perihelion period was 334, and of the aphelion 254; and deduces therefrom that the number of meteorites which fall in-

creases as the earth approaches the sun. From various considerations Mr. Hennessey concludes that the sun's distance from the shooting stars, or meteorites, which fall so abundantly both in November and August, or in the perihelion and aphelion periods, is less than the mean distance of the earth from the sun; and hence that if the mean distance of the earth had been greater at some former epoch than it is now, the effect ought to be similar to that observed in the increase of its distance in passing from the perihelion to the aphelion,—namely, a diminution of ærolites. If, then, it be conceded that no ærolites did fall in the early geological epochs, it would appear probable that there has since been a similar diminution of the earth's distance from the sun. The general phenomena of the early formations, however, exhibit evidences of a higher temperature; and it is, therefore, reasonable to conclude that internal heat was the cause of elevated superficial temperature, which heat diminished to a minimum at the glacial epoch, when the gradual approach of the earth to the sun restored the balance and produced the present relations of temperature.

It now remains for me to notice the second great branch of our subject—natural or organic geology; and I regret that the contributions from our members during the present season have not been so extensive as to justify me in any very lengthened discussion of it. At the March meeting, Professor Oldham described the geological relations of the district extending from the Skerries northward beyond Balbriggan, the strata of which are much disturbed and altered by the intrusion of igneous rocks. He pointed out the fossiliferous nature of some of the rocks—a fact first made known by the Government geological survey; but I regret that he did not leave sufficient details to allow me to point out the nature of the fossil evidence thus obtained. In his last communication to the Society, in December last, he states that beds occur near Balbriggan which, from their fossils, appear to represent the upper limestone of the carboniferous system, and that the old slates east of the town of Wexford are shown, by the fossiliferous beds which accompany them, to be part, not of the Cambrian, or lower portion of the Silurian, but probably of the middle portion of the series. Here, also, I have no details on which I can offer further remarks. The labours of Mr. M'Adam, including his contribution of an

extensive list of pleistocene fossils from the mud and gravels of Belfast, I have already noticed; and I will only here request the attention of my friend, as regards his physical reasonings, to the paper by Mr. James D. Dana, on denudation in the Pacific.* That writer appears to consider that "running water of the land" was the great agent in the formation of valleys, or, in other words, of denudation. He, however, observes that—

"Although the sea can accomplish little along coasts toward excavating valleys, yet when the land is wholly submerged, or only the mountain summits peer out as islands, the great oceanic currents sweeping over the surface, and through channels between the islands, would wear away the rocks or earth beneath. From the breadth and character of such marine sweepings, we learn that the excavations formed would be very broad rounded valleys, and their courses would correspond, in some degree, with the probable directions which the currents of the ocean would have over the region in case of a submergence. Moreover, where there are different open channels for the ingress of the sea, having free intercommunication, there are often *strong currents connected with the tides, and consequently much erosion.*"

The tidal wave has, indeed, a manifest and great effect in the removal and arrangement of detritic matter, and ought not to be neglected in any consideration of the nature and formation of gravel deposits, or in a discussion of the organic remains they may have enveloped.

In April, 1850, I communicated to the Society some remarks by my relative, Mr. Richard Rubidge, a highly talented medical practitioner in the Cape country, on some facts connected with the geology of that portion of South Africa, and at a subsequent meeting I described some of the fossils he had sent to me. In the fossiliferous portion of the district, consisting of sandstone, marl, and shale, there are remains of many marine mollusca; and near the Sunday River, vegetable impressions. The latter will be hereafter more particularly referred to; and at present I shall only notice some few of the marine fossils which support Mr. Rubidge in placing the deposit containing them in the lias, or, at least, in a portion of the oolitic system.

1. Ammonites carusensis—D'Orbigny. The ribs appear to be interrupted, as in D'Orbigny's species, in passing over the front;

* American Journal of Science. January, 1850.

but it is closely allied to A. planicostata of Sowerby, and is evidently an oolitic form. D'Orbigny species was associated with gryphœa incurva in the lower lias of D'Angy-sur-Aubois.

2. A. Asterianus—D'Orbigny. The group to which this belongs is represented by several species in the oolitic system, though the present species is ascribed by D'Orbigny to the lower section of the neocomiens. The specimens are all very much larger than that described by D'Orbigny, and it is therefore very probable that it is nearly allied to, but not identical with his species.

3. Gryphæa incurva.

4. Pholadomya ovalis of Sowerby.—A fossil of the upper oolite.

5. Modiola plicatilis, Goldfuss.—An oolitic fossil.

6. Lyrodon Herzegii (Hausmann and Goldfuss).—A very beautiful species, which was also obtained by Hausmann, who considered the deposit green sand, at Sunday River. It belongs to the family of trigonidœ. The geologist will see in these fossils, which, with the exception of the Lyrodon, have all been figured from localities remote from the present one, an exemplification of the uniformity which has been supposed to characterise the faunæ of past epochs, and to be contrasted with the individuality of many local faunæ of the present epoch; but which is now less insisted on, as our most able Patœontologists consider the range of species equally great in our present system as it ever was.

Of labours not immediately connected with our own members, I shall only notice those which have a very general bearing on our science, the first of which will be the paper of M. Adolphe Brongniart, on "Periods of Vegetation, or Successive Floræ of the Earth," in the Annales des Sciences Naturalles, and subsequently in the Annals of Natural History.

The first object in studying fossil vegetables is, like that of studying animal fossils, to determine their relation to still existing organisms; but when this has been done it is necessary to examine the relations they bear to the strata in which they are found; and in doing this it is discovered that there are great differences in the nature of the vegetables which are successively developed, or which correspond to the successive epochs of the earth's history. In other words, that the plants which appear after each great revolution of the earth's surface differ materially from those which preceded it. Nor are the differences merely slight varia-

tions of a common type, but are usually very important changes, either new genera, or even new families, replacing those which have been entirely destroyed; or perhaps one family rich in genera and species, becoming reduced to very few species, whilst another, scarcely represented by a few individuals, suddenly becomes abundant and predominant.

These changes may be noted in the mere passage from one formation to another; but, enlarging the field of observation, this more general and important result may be stated—that, in the earliest ages, acrogenous cryptogamous vegetables prevailed, the ferns and lycopodiaceæ, or club masses; that next gymnospermous dicotyledonous plants, the cycadeæ and coniferæ, became predominant, without any mixture of angiospermous dicotyledons; and, subsequently, during the chalk, that angiospermous dicotyledons and monocotyledons appeared, and became predominant—a fact which M. Brongniart represents by dividing the long geological series of past ages into three periods: the reign of acrogenes, the reign of gymnosperms, and the reign of angiosperms—expressions which do not signify the positive exclusion of any one order, but merely the predominance of the others, excepting that angiospermous plants appear to have been nearly deficient in the two first reigns; for if their presence be admitted their forms were very different from those of existing angiosperms, and more approximating to monocotyledons than dicotyledons.

In the first reign, or that of acrogenes, M. Adolphe Brongniart includes the Silurian, carboniferous, and Permian systems—a result quite conformable with that obtained from animal fossils, as there is certainly a strong relation between the faunæ of these three epochs. In the second, or that of gymnosperms, he includes the trias and oolitic periods; and here, again, the analogy is supported by other organic fossils. In the third, or reign of angiosperms, he includes the cretaceous and tertiary—a result not so distinct as the preceding, though in the chalk a great approximation to the existing order of creation may be reasonably inferred to begin from the evidence both of vegetable and animal remains.

In the reign of the acrogenes, or carboniferous epoch, the most striking characters are the numerous species of ferns, the great development of the lycopodiaceæ and the arborescent form of the lepidodendra, to which may be added the occurrence

of anomalous families of gymnosperms,' which are totally distinct from those now existing, having closed their existence with the reign of acrogenes, such as sigillariæ, næggerathiæ, and asterophillite. During the whole of this great period, from the Cambrian up to the Permian inclusive, there appears to have been no change in the greater characteristics of the flora, though certain genera and certain specific forms have prevailed more in one part of the series than in another. For example, the lepidodendra and calamites are more abundant in the more ancient, and the sigillariæ and coniferæ in the middle and upper beds of coal deposits. If the fossil flora be compared with the recent, two remarkable facts become apparent. The absolute number of species is small in comparison, since the carboniferous fossil flora of Europe contains only 500 species, whilst the number observed in the recent flora is 11,000, viz:—6,000 phanerogamous and 5,000 cryptogamic; but if the ferns alone are compared the proportions are reversed, as the fossil flora yields 250 species, and the recent only 50. And, in like manner, the coniferæ and ephedreæ of the carboniferous epoch amounted to 120 species, whilst those of the present epoch are only 25.

This preponderance of cryptogamic acrogenes establishes an analogy between the vegetation of this early period and that of the small islands of the equatorial zone and southern temperate zone, in which a maritime climate is most fully established; but with this exception, that in the existing epoch it is not connected with an exclusion of phanerogamous plants. In the Permian period the fragments, as it were, of this ancient flora remains, but no traces of it are discovered in the trias; a conclusion which must be received with much caution.

The floral characteristics of the several tertiary deposits are thus stated by M. Adolphe Brongniart:—

1. In the eocene epoch, the presence of palms, as yet distinguished by extreme rarity, being limited to a small number of species. The predominance of algæ and marine monocotyledons, which may be attributed to the great extent of marine deposits during that epoch. The great number of conifers, and the presence of several extra European forms, principally resulting from the discovery of fossil fruits in the island of Sheppy.

2. For the miocene—The *abundance* of palms; the existence of a great number of extra European forms of plants, united with the genera of temperate and cold climates, and the presence of the genus Steinhauera, which appears to M. Brongniart a rubiaceous plant, allied to the morindæ.

3. For the pliocene epoch—The great preponderance and variety of dicotyledonous plants, the rarity of the monocotyledons, and especially the absence of palms; the general analogy being with the plants of the temperate regions of Europe, of North America, and Japan. Of curious deficiencies may be noticed the total absence, so far as our present knowledge, of compositæ, campanulaceæ, personatæ, labiatæ, solaniæ, boragineæ, &c.

The pliocene flora of Europe is distinguished from the recent, by the absence of mosses and ferns, and from the miocene and eocene, by the absence of palms.

In the modern tertiaries of the Antilles, however, palms are found, so that at that epoch they already there possessed the characteristics of an equatorial zone, whilst in Europe they were marked by those of the temperate zone.

Whilst, therefore, in the more recent tertiary epoch the general distribution of vegetables resembles that of the existing period, none of the plants of the one are actually identical with those of the other, unless the comparison be carried beyond the range of the actual fossil flora; for example, by comparing the fossil plants of Europe with the recent of America.

M. Jules Thurmann has published an extensive work on Phytostatics, in reference to the Jura and adjacent countries, principally with a view to determine the influence of the subjacent rocks on the dispersion of vascular plants; and of this work an abstract has been given in the Annales des Sciences Naturelles.* His object is to demonstrate, first, that there is an appreciable relation between the dispersion of species of plants and the subjacent rocks; and, secondly, that such relation depends on an influence connected with the physical properties, and not with the chemical composition of the rocks. Assisted by many French and Swiss botanists living in the Jura district, the author has compiled a complete table of the Jurassic flora, and added to it

* Annales des Sciences Naturelles. December, 1849.

one of species which are not truly Jurassic, but grow in that region; so that the whole affords a basis of comparison by which the facts of dispersion, as regards each species, in the various chains and valleys round the Jura, may be tested and established. M. Thurmann then discusses these facts of dispersion in reference to their causes, whether connected with climate or with soil. In the first place, he determines all the effects which may be reasonably ascribed to climate, in reference to annual temperature, differences between summer and winter temperature, rains, snows, springs, &c., and also the effects of latitude and altitude, and represents these elements of comparison on a topographical map of the Jura, by zones of colour and by thermometric curves, so that the proportion of the total effect due to these causes can at once be seen. In the next, he studies the subjacent rocks of the country, their distribution and principal *physical* and chemical properties, and adopts for them too distinct classifications—the one chemical, as calcareous, silicious, silicio-aluminous; the other physical, as eugeogenic and dysgeogenic. Amongst the rocks chemically considered, there are some which are easily disintegrated by atmospheric agencies, and give to the soil greater powers of division and of absorption of moisture—as, for example, sandstones, some granites, clays, &c.—and these may be subdivided into pélogènic or those which produce an earth soil or mould, and psammogenic which produce a sandy soil; and there are others which break up with difficulty, and yield to the soil only a close and stiff detritus, such as compact limestones, some porphyries, basalts, &c. The soils of the first class are more fresh and moist, and those of the second more dry and barren. The country was then mapped and coloured in groups characterised by these properties; thus, for example, the Jura and the porphyritic portion of the Vosges are dysgeogenic districts, whilst the tertiary valleys, the granitic Alps, the classic Vosges, are eugeogenic, partly psammogenic, and partly pélogènic. The Jura, in reference to its levels and latitudes, is first divided into four zones; and it is observed, that where the structure of the chain is the same, certain species of plants regularly appear at fitting exposures within them. The lower region extends to 400 metres, and is characterised by vineyards and maize crops, which encircle, like a girdle, the hills; the

second, from 400 to 700 metres, has neither vines nor pines, but is clothed with evergreens; the third, or mountain region, from 700 to 1,300 metres, is characterised by pines and the great gentian; and, lastly, the Alpine region, from 1,300 to 1,800 metres, is pasture grass. These regions are so neatly marked, that they may be recognised by the vegetation from about twenty-four test or characteristic plants. Having established these relations, and extended them from the Jura to the adjacent districts, M. Thurmann takes up the great question of the influence of the subjacent rocks on the distribution of the plants. This influence, he shows, may be traced in the most striking manner, even at the line of contact of two rocks suitably distinct from each other; and having studied the peculiar sympathy, as it were, or dislike of certain plants to certain rocks, he shows that the facts of dispersion prove that this elective tendency is exercised not so much in reference to the chemical as to the physical characters—the appearance or disappearance of plants depending not so much on the recurrence of calcareous or silicious soils, as on those possessed of eugeogenic or dysgeogenic properties; and he therefore classes the plants as hygrophiles which elect moist and fresh or eugeogenic soils, and xerophiles which elect the drier or dysgeogenic soils. The general comparison of the results of all these examinations, conducted on the graphic principle now so familiar both to mathematicians and statists, leads them to this important result. The state of the vegetation, or flora, of a country—that is, the dispersion and arrangement within it of plants—depends primarily on latitude and altitude, which are the principal elements or factors of the climate; and, secondarily, on the subjacent rocks: or, if the climate (made up as the effect of all its factors) be the same, the dispersion of floral species depends on the mechanical properties of the subjacent rocks, or on the strength, state of division, and absorbent power of the soils produced by their decomposition.

This work of M. Thurmann is of the highest value to the philosophical geologist. In applying its principles to practice it must be remembered that the detritus of rocks is rarely stationary, but is first transported from high to low lands, from the mountain top to the shores of the ocean, and there is spread, by tidal and other marine currents, over its bottom. Such transport

of detritus has been in progress since the earliest geological epoch, and must, therefore, from the beginning, have affected, more or less, the dispersion of plants. If, then, we compare these observations with the facts I have before noticed of the recurrence of the phenomena of elevations, and the intrusion of igneous matter in certain definite directions, we may reasonably imagine that as these points were elevated above the level of the sea, they became centres of vegetation; and that the grouping of species commenced in relation to the properties of the several rocks; and that the dispersion from these centres followed the direction and modification of the peculiar detritus or drift suitable to their organic peculiarities. In like manner it is easy to imagine how the conditions which had fitted a soil for the maintenance of one class of vegetation may, by physical changes, have been rendered unfit for its support, and hence the sudden disappearance of a flora in the passage from one geological formation to another.

It is not to be supposed that M. Thurmann intends to deny any chemical influence, or influence of composition, of the soil on vegetation. On the contrary, he distinguishes it where it exists, and first eliminates it, as mathematicians would do, before he draws his conclusions. In fact, the quantity of mineral matter which exists in the ashes of vegetables of all kinds, demonstrates their action on the soil, and, in like manner, a reaction of the soil upon them. The necessity of attending to this reciprocal connexion between the soil and the plants growing upon it, is every day becoming more evident, as agriculture is assuming a decidedly scientific character, and the farmer is forced to seek in the knowledge of the chemist and geologist a more sound basis for his practical operations than could be obtained from the mere trial and error of a rude agricultural system. M. Boussingault, who is remarkable in France for the combination of great farming and chemical knowledge, has paid great attention to this subject; but I shall merely quote the following results as illustrative of it. In one year, each of the following crops takes from the soil per acre:—

The Vine,	...	...	15·3 lbs. of Alkali.
Potatoes,	...	...	58·8 „
Beet Root,	...	...	84·00 „
Barley,	...	...	25·20 „

The connexion, therefore, between inorganic and organic nature, and the reciprocal action of the one upon the other, are distinctly manifested in the vegetable kingdom; nor is the dependence of animals on the elements in which they live less remarkable. M. Agassiz,* whilst admitting fully the necessity of resting any natural classification of animals on their internal structure, as the only safe foundation, urges the propriety of again returning to some consideration of the natural relations which exist between animals and the elements in which they live: for though, as he observes—

"The mere living in water or upon dry land is in itself of slight importance, as there are so many animals which dwell in the two elements, although having the same *identical* structure, it should not be overlooked, that the greater number of aquatic animals have structural peculiarities common to all, and that the same is the case with the terrestrial or aereal animals; and that, not merely in reference to their respiratory apparatus, as the greater pressure under which aquatic animals are maintained throughout their life, modifies in many other respects their organization."

It is thus that whilst anatomical structure decides the zoologist in forming his classes of mammalia, birds, fishes, reptiles, insects, mollusca, &c., he is forced to observe that a modification of the normal structure was necessary to adapt it to a terrestrial or to an aquatic life. Having premised thus much, M. Agassiz endeavours to show that the aquatic type is always an inferior degree of organization. Taking, for example, the four great divisions of the animal kingdom, as adopted by him, namely, the radiata, including the three classes of polypi, jelly fishes, and echinoderms; the mollusca, including cephalopoda, pteropoda, gasteropoda, acephala and brachiopoda; the articulata, including anthropoda, crustacea combined with cirripedia, and insects; and, finally, the vertebrata—he finds the lowest grade of structure in the aquatic type, with some exceptions, such as the cephalopoda as a branch of the mollusca—an exception which deserves the special attention of the philosophic geologist. In like manner, the fluviatile types rank higher in structure than the marine.

* "The Natural Relations between Animals and the Elements in which they Live," by L. Agassiz.—*Silliman's American Journal*, May, 1850.

"These views," M. Agassiz observes, "are fully sustained by the order of succession of these great types of the animal kingdom throughout the earlier geological periods; for, as it is already ascertained from zoological comparisons, that the earlier types in each class rank lower than their present living representatives, we have further evidence, from the circumstances under which they live, that they were all aquatic and marine in the earliest periods, and that fluviatile and terrestrial types have followed only at later periods. Without alluding to those classes in which the gradation of fossil types is less distinctly shown, let me only recall the crinoids among echinoderms, which for so long time prevailed, to the almost entire exclusion of all other families among acephala; the great prevalence of brachiopoda in the oldest deposits, and the first appearance of naiades in tertiary beds; the large number of branchiate gasteropoda up to the time of the tertiary period, when limneæ and helices made their first appearance; the earlier development of crustacea with more uniform joints, and the appearance of insects of the tribe of scorpions anterior to that of the winged families, among which the neuroptera seem to be the first to increase in number; and the late occurrence of the sucking tribes in tertiary beds, and there will be no doubt left that the gradation of structure is intimately connected with the extension of continental lands, and that the present connexion of animals with the surrounding media in which they live agrees also with their natural gradation."

It is rather to this particular conclusion than to the general reasons of our author that the geologist should direct his attention. The apparent exception in the cephalapoda, as a branch of the mollusca, is, indeed, a strong confirmatory proof that the gradation of structure was not one of mere progressive improvement, but was the result of adaptation to the gradually altering circumstances of the earth's surface. The cephalopoda are highest amongst mollusca, and almost rival in the complication and development of their structure some of the vertebrata—and yet they are exclusively marine. It was, however, in the earlier stages of the earth's history that these animals exhibited their fullest development; and when we contemplate the numerous genera which have been discovered in the strata of the earth, from the orthoceridæ and nautilidæ of the earlier formations, to the baculidæ and ammonidæ of the chalk, and the singular variations from the more simple forms which they exhibit, it is impossible not to see that they indicated a modification of a normal form calculated to place the resulting organization in relation to some pecu-

liar circumstances of an aquatic or marine period, or, as M. Agassiz expresses it—

"The peculiar relations of this class to its type must be rather appreciated under the point of view of the conditions which prevailed in former ages, when the ocean covered more extensively the whole surface of the globe than at present; so that the type, with its high organization, must be considered more with reference to its development in former ages, than to what it is now, as at present the class is proportionably reduced; and it is well known, that in earlier periods, however high animals might have ranked by their structure, they were all marine, as we know fishes to have been the only representatives of the vertebrata in the earlier periods."

In truth, were it necessary to vindicate the claims of divine power, as manifested in creation, this modification of one organic type through a vast variety of forms, would afford one of the strongest arguments in its favour; and we may at least conclude from it that the necessary relations of the animals to the medium in which they were to live, led to the high and varied development of lower organic types rather than to the adoption of higher types, which were suited to circumstances not yet existing. M. Alcide D'Orbigny* has published two essays on this subject. The first treats on the successive progress of organization on the surface of the earth from the most ancient geological epochs to the existing one. The mode of discussing the question is different from that adopted by M. Agassiz, but is equally interesting. M. D'Orbigny first states, that in the animal kingdom the number of orders continued, with only slight exception, to increase in successive epochs, the numbers being as here shown:—

In the Palæozoic epoch,	31
In the Triasic "	21
In the Jurassic "	41
In the Cretaceous "	41
In the Tertiary "	71
In the existing "	76

In the aggregate, therefore, the quantity of animal forms increases, in respect to orders, on approaching the existing epoch.

* "Annales des Sciences Naturelles," April, 1850.

M. D'Orbigny next demonstrates, that though the total number of orders has thus increased, there is a very remarkable difference in the manner in which the several orders have been developed at successive epochs, some having obtained their maximum number of genera at some past geological epoch, and having now dwindled down to a comparatively small number, whilst others have continued to increase in number of genera up to the present epoch; or in other words, there are thirteen orders in a state of successive decrement, and sixty-four orders in a state of successive increment. If, then, more than one-sixth of the whole number of orders is in a state of decreasing development, and further, if this decrease has commenced in some at a very remote epoch, it is manifest that all the series of the animal kingdom have not advanced in one uniform progression of development. In the palæozoic period six orders had already attained their maximum of development, and begun to decrease, namely, placoid and ganoid fishes; trilobitic crustacea; tentaculiferous cephalopodes; brachidous brachiopoda, and fixed crinoids; or representatives of each great zoological division. In the Jurassic period, two orders began to diminish—namely, the saurian reptiles and the free crinoids. In the cretaceous period, four orders have passed their maximum of development and begun to wane—namely, the cirrhidous brachiopoda, the bryozoa, one section of foraminifera, and the sponges; and finally, in the tertiary period, two orders enter upon the wane—namely, the pachydermata and the edentata.

This result M. D'Orbigny considers in opposition to the theory of progressive perfection in development, and he then proceeds to examine the position of the thirteen decreasing orders in their respective branches of the animal kingdom, with a view to the same question. Beginning with the radiata, he finds that four orders are in a state of decrement, and twelve in that of increment; and of those in decrement whilst two orders belong to the lower forms of radiata, the echinoderms, which ranked as the highest, have furnished the others, one order having attained its maximum development many geological stages before the amorphozoa, which are at the very bottom of the animal scale. The radiata, therefore, do not conform to the supposed rule of progressive perfection of development. In the mollusca, four orders are in decrement,

and ten in increment, and those in decrement include the tentaculiferous cephalopodes, which attained their maximum of development in the silurian or earliest known zoological epoch, being two stages before the maximum development of the brachidous brachiopoda, twenty-one stages before that of the cirrhidous brachiopoda, which are inferior to the former, and twenty-two stages before that of the bryozoa, which are the lowest in organization of this branch of the animal kingdom. In the articulata the comparison must be imperfect from the perishable character of their structure, so that only one order appears in decrement, and eighteen in increment. The order in decrement is that of the trilobites, which belongs to the crustacea, and is more perfect in organization than the annelida and cirrhipeda, although the trilobites attained their maximum of development in the silurian epoch, and disappeared almost immediately afterwards, whilst the annelida and cirrhipeda have only attained their maximum in the existing epoch. In the vertebrata five orders are in decrement, and twenty-three in increment, being a ratio of nearly one to five, which is certainly very great in a branch so high in organization, and including man. In examining the orders in decrement, two belong to fishes, the placoids and ganoids, which far from being at the bottom of the scale in organization, are superior to the pleuronectidæ, still in a state of increment; and even include the squalidæ, which are superior to all other fishes in organization, so that in this class the highest development of the most perfect form took place at the earliest, and not at the latest epochs. In reptiles, the saurians which attained their maximum development long since, and now are in decrement, are superior both to the ophidia or serpents, and the batrachea or frogs, which are both in a state of increment; and, finally, in the mammifera, the pachydermata or elephants, and the edentata, are superior in perfection to the cetacea, which are still in a state of increment. It seems, therefore, evident, that there has been no general advance of organic perfection in successive epochs, but that some orders of a high degree of organization have anticipated others of a much lower degree, and that in each great branch of the animal kingdom the orders which have first attained their maximum of development have not been the lowest, as to organic structure, of that particular branch. It appears to

me, that this reasoning is not only opposed to the theory of progressive development, but founded as it is on facts, supports the conclusion I have already drawn from the essay of M. Agassiz, that organic perfection was attained at every epoch, estimating that perfection by the adaptation of the organic structure to the circumstances in which the animal was required to live. The second essay* of M. D'Orbigny is equally important in reference to this subject. In the thirty-one orders which have been already discovered in the palæozoic strata, each great division of the animal kingdom is fully represented, namely—the radiata by eight orders, the mollusca by nine, the articulata by eleven, and the vertebrata by three, so that the organization of the earliest periods was by no means confined to the lowest forms of animal life; and when these divisions are individually examined, it is found that of the eight orders of radiata, four belong to the echinodermata or the highest, and only two to the amorphozoa, or the lowest of the division. Of the nine orders of mollusca, some represent each class, and the most perfect class, the cephalopoda, is at its maximum of development in combination with a similar high development of the most perfect section of brachiopoda; of the articulata, some are also found to represent each class, and the coleoptera, or the most perfect, are amongst the insects; and of vertebrata, fishes and reptiles appear to have commenced with a great development of their higher forms of organization. The mammalia alone attained their highest perfection and their most extended generic development in the existing epoch, and were totally absent from the palæozoic fauna; yet even in this case, true mammals commenced not with the lowest, but with a high form of organization, namely—with the pachydermata and edentata. In like manner, birds commenced in the triasic period, and exhibited in the waders an order quite as perfect as the palmipedes of the chalk, and other orders subsequently developed; and chelonian reptiles appeared also in the trias or long before much more imperfect orders subsequently developed; so that the supposed progressive advance of organization through successive ages of the world, from a low type to one more perfect, rests only on the mammifera, and may be considered

* Recherches Zoologiques sur l'instant d'apparition dans les ages du monde des ordres d'animaux comparé au degré de perfection de l'ensemble de leurs organes Annales des Sciences Naturelles.—Ap. 1850.

an exception, principally founded on the late appearance of man upon the earth. The several divisions, and even the classes of the animal kingdom, have had a parallel development at each epoch of the earth's history, and the peculiar preponderance of some of them, or the absence of others, must be ascribed not to the necessity of some law of progressive improvement, but to the required relations of their organization to the elements or circumstances of their intended existence.

The remarkable development of the pachydermata just before the commencement of the existing epoch, and their sudden diminution and almost disappearance in regions where they had abounded, is a fact of the highest interest, and is thus stated by M. Paul Gervais.* Of hoofed animals, the ancient French fauna possessed eight species of proboscidea, belonging to the genera elephas, mastodon, and dinotherium, all of which are extinct; forty-nine or fifty species of herbivorous pachyderms, of which only the ass and horse now exist; of omnivorous pachyderms thirty-five species, of which the boar and hog only remain; and of ruminants fifty species, eleven of which still live, either as wild or domestic animals, in France, and three, though extinct in France, are still found alive in other parts of Europe. Is it unreasonable to attribute the sudden disappearance of 125 or 127 species of animals of the great order of hoofed animals, including so many of large size, and the preservation of genera so valuable for domestic purposes as the ox, the goat, the sheep, the camel, and the horse, to a wise preparation for the ultimate occupation of the earth by man? And can we doubt that those powers of destruction which were bestowed on many of the gigantic reptiles of earlier geological epochs, have been replaced by the exercise of a lesser amount of physical force, guided by a higher intellectual power, as exhibited in man, the last and most perfect work of organic creation?

I have endeavoured thus far to set before you some of the more general and philosophical results which are the consequents of careful inquiry into the organic peculiarities of the earth in successive ages; and it is my intention to defer, until I again address

* Comptes Rendus. October, 1850.

you, an analysis of these detailed Palæontological works which are still in progress, contenting myself at present with only a few general remarks. In setting before you the views of M. Alcide D'Orbigny, I have had occasion to use the terms brachidous and cirrhidous brachiopoda, and I must therefore make you aware of the classification which that author has proposed for this class so important to the geologist. After commenting on the works of preceding authors, he points out the remarkable fact, that whilst one set of writers has attended almost exclusively to the anatomy of living species, the other, and far more numerous set, has diligently studied the external characters alone of the shells of extinct species. It is thus, he observes, that the arms, on the presence of which the name brachiopoda was established by Dumcril, and adopted by Cuvier, Owen, &c., seem to be almost forgotten; and the mantle so intimately connected with the organs of respiration, on which M. Blainville founded his term palliobranchiata, "has been scarcely mentioned out of the works of Cuvier and Owen." M. D'Orbigny, on the contrary, considering the presence or absence of arms to have a material effect on the extension and zoological characters of the mantle, adopts them as the basis of his proposed classification. He has thus two great divisions—

1st, Brachiopoda brachidea.—With arms; the borders of the mantle being only slightly developed, and the shell always symmetrical.

2nd, Bracchiopoda cirrhidea.—Without arms; the borders of the mantle much developed and strongly ciliated; shell rarely symmetrical.

The first division is subdivided according as the arms are fleshy, being free in their whole length, very extensible, and provided with rather short ciliæ; or fleshy, being sometimes supported on a shelly framework and always fixed, not extensible, and provided with long ciliæ. The first subdivision is divided into two sections, in the first of which the arms are rolled up in the same plane, and not supported by the internal processes of the lesser valve; and in the second, the arms are rolled up laterally and supported by the internal processes of the small valve.

The first section contains two subsections, namely one in which the shell has no hinge, and is composed of families 1 and 2,

the lingulidæ and the calceolidæ; the other, in which the shell has a hinge, and is composed of families 3 and 4, the productidæ and the orthisidæ. The second section is composed of families 5 and 6, the rhynchonellidæ and the uncitidæ. The second subdivision of the brachiopoda brachidea is also divided into two sections, in the first of which the fixed arms are supported in a shelly framework, and the shell is terebratuliform, has a hinge, and in substance is shelly, perforated, or fibrous; whilst in the second, the arms are fleshy, spiral, and united together, not supported by a shelly framework—the shell being conical, without hinge, deltidium, or area, and in substance either horny or perforated. The first of these sections contains also two subsections, one in which the framework which supports the arms is spiral, and the texture is almost always fibrous, being composed of family 7, the spiriferidæ; and the other, in which the framework is bent at angles, and the texture is always perforated, being composed of families 8 and 9, the magasidæ and the terebratulidæ. The second section is here also simple, and is composed of families 10 and 11, the orbiculidæ and the cranidæ.

The brachiopoda cirrhidea are divided into two subdivisions, in the first of which the shell and animal are regularly formed of symmetrical parts, in pairs, and the shell is always perforated, and never channelled, this subdivision being composed of family 12, thecidæidæ; in the second, the shell and animal are irregular, not being formed of symmetrical parts, in pairs, and the shell is not punctuated, and often channelled, the subdivisions being composed of families 13 and 14, caprinidæ and radiolidæ.

The characters of the families are thus given:—

1. Lingulidæ.—A pediculated external muscle passing between the two valves; shell horny; the beaks of both valves are equally grooved for the passage of the muscle, as in Lingula of Bruguiere; or the beak of one valve only, as in Obolus of Eichwald.

2. Calceolidæ.—There is no pedicle or external muscle; the animal and shell are free, and the texture is fibrous, as in Calceola of Lamarck.

3. Productidæ.—No opening for a muscle; animal and shell free; shell often tubular or perforated. The family thus divides itself into genera: when provided with external tubes over the

whole surface, the hinge area being scarcely visible, Productus (Sowerby). When the tubes occur only along the hinge border, and the area is strongly marked, Chonetes (Fischer). When without external tubes, the shell not being perforated, and the two valves arched, but not bent, Leptœna (Dalman).

4. Orthisidæ.—An opening for the passage of a muscle; animal fixed; shell always fibrous, but not perforated. When the opening, which is round, is placed at the summit of the large valve, without trenching on the hinge area, Strophomena (Rafinesque). When the opening is placed below the summit of the large valve, and in the area; if raised, and in the centre of an entire semi-deltidium, Orthisina (D'Orbigny); if triangular, and occupying the whole breadth of the area, there being no deltidium, Orthis (Dalman).

5. Rhynchonellidæ.—An opening for the passage of an external muscle; animal fixed. When the opening is close to the hinge, there is no area, and the summit is entire, Hemythiris (D'Orbigny). When the opening is separated from the hinge, and placed under the beak of the great valve: if surrounded by a raised margin, the deltidium is double, and there is no area, Rhynchonella (Fischer); if the opening has no raised margin, the deltidium is simple, and there is an area, Strigocephalus (Defrance). When the opening, separated from the hinge, is placed at the extremity of the beak of the great valve, Porambonites (Pander).

6. Uncitidæ.—No opening for the passage of an external muscle; animal free; when the beak is detached, salient and hollowed below, Uncites (Defrance). When the beak is turned over on itself, if the processes of the arms are free in the middle of the small valve, and the interior of the valves has no plates or laminæ, Atrypa (Dalman); if the processes of the arms are fixed to the small valve by a vertical plate, and the interior of the valves is provided with plates, Pentamerus (Sowerby).

7. Spiriferidæ.—When there is no opening in the shell for the passage of a muscle; the animal is free, and the shell fibrous, Cyrthia (Dalman). When there is an opening for the passage of a muscle, and the animal is fixed: if the opening is triangular close to the hinge, there is no deltidium, and the shell is fibrous, whilst the opening trenches upon both valves, Spirifer (Sowerby);

or, if the shell is perforated, and the opening trenches on the great valve only, Spiriferina (D'Orbigny). If the opening be round, distant from the hinge, placed under the beak, in the middle of a deltidium and area, the spiral cave having its summit inferior, Spirigerina (D'Orbigny); or, when placed at the summit of the beak, without deltidium or area, the spiral cone having its summit on one side, Spirigera (D'Orbigny). The shell of both these genera is fibrous.

8. Magasidæ.—Opening close to the hinge and no deltidium: when elongated, the beak being entire, and the hinge without ears, Magas (Sowerby) ; when round, the beak being truncated obliquely by it, and the hinge is provided with lateral ears, Terebratulina (D'Orbigny).

9. Terebratulidæ.—Opening placed at the extremity of the beak, and separated from the hinge by a deltidium. When without area, the opening being round, and trenching more on the beak than on the deltidium, which is in two pieces, Terebratula (Brug.). When the area is considerable, if the deltidium is composed of two pieces, and the opening trenches more on the deltidium than the beak, Terebratella (D'Orbigny). If the deltidium has only one piece, and the opening is round and trenches on both beak and deltidium, Terebrirostra (D'Orbigny). Or, when the opening is a slit, and only trenches on the external portion of the beak, leaving the deltidium entire, Fissirostra (D'Orbigny.)

10. Orbiculidæ.—An external muscle, proceeding from an opening in the lower valve; the shell free. When the shell is testaceous and perforated: if the peduncle of the muscle of attachment proceeds from an opening in the beak of the lower valve, Siphonotreta (Verneuil et Keyserling); if the peduncle proceeds from a lateral opening at the summit of a conical valve, Orbicella (D'Orbigny). When the shell is horny, and not perforated, if the pedunculated muscle issues by a lateral opening in the lower concave valve, Orbiculoidea (D'Orbigny); if the muscle is not pedunculated, and issues from a lateral opening which occupies the external portion of a flat valve, Orbicula (Lamarck).

11. Cranidæ.—No external muscle, the shell fixed, in texture perforated, thick, and with a ramified limb, Crania (Retzius).

12. Thecidæidæ.—When the shell is free, and has an attaching

muscle which passes through a large opening of the great valve, and there are internal salient processes, Megathiris (D'Orbigny). When the shell is fixed, and there is no external muscle of attachment, but there are two internal muscles, corresponding to channels, hollowed in the upper valve, Thecidæa (Defrance).

13. Caprinidæ.—Internal canals, penetrating into the substance of the shell by openings of the limb. When the upper valve alone has internal canals: if the canals are ramified, and communicate with the exterior of the shell, the whole shell being conical, Hippurites; if the canals are simple, not ramified, are compressed, and with communication with the exterior, the general form of the shell being spiral, Caprina (D'Orbigny). When both valves are provided with internal canals, if the canals are unequal and round, the lower valve conical and the upper spiral, Caprinula (D'Orbigny); if the canals are equal and capillary, the lower valve spiral and the upper valve opercular, Caprinella (D'Orbigny).

14. Radiolidæ.—No internal canals in the shell; limb simple or ramified. If the two valves are conical, the summit of the upper being central, and the limbs ramified and very lamellar, Radiolites. If the two valves are twisted, the summit being lateral, and often spiral, and the limb is simple, and not lamellar, Caprotina (D'Orbigny).

These characters I have extracted from the papers of M. D'Orbigny, in "Annales des Sciences Naturelles," May, 1850, which were originally read to the French Academy in 1847, and form part also of the great work by the same author, "Paléontologie Française," still in course of publication. It appears to me that the essay of M. D'Orbigny is the most comprehensive effort yet made to reduce to order this class, so interesting to geologists, and to combine together a due consideration of external form, and an attention to important anatomical characters. The result may not, indeed, be without defects; and the similarity of some of the names which vary round a common radical, will certainly require great caution to avoid confusion; but, such as it is, it must be received as a most valuable contribution to palæontological science. Such, indeed, is the accelerating progress of this science, that M. D'Orbigny has already found it necessary to form one new genus,

which he has separated from Radiolites, under the name of Biradiolites, and to admit another by the name Requienia (Mathéron), as distinct from Caprotina. In the Biradiolites are always observed two longitudinal bands, which extend in both valves from the beak to the lip, and are analogous to the two furrows of the Hippurites—such bands are never seen in true Radiolites. Requienia is distinguished from Caprotina by the obliquity of its valves, the shell always resting on its sides, by the absence of large internal teeth in the hinge and of internal conical cavities, which are replaced by isolated laminæ, or plates, which extend from the border to the summits of the beaks. The internal differences which are here cited between Caprotina and Requienia are very great, and show the difficulty of constructing any system which shall embrace every possible variety of form and structure without violating some of the analogies of nature. As the "Paléontologie Française" is still in course of publication, I shall only deviate from my rule so far as to point out some of its more general results. In the cretaceous formation, M. D'Orbigny describes 161 species of brachiopoda, which he thus apportions to the several stages, as characterised and named by him, of that formation:—

Neocomien	Lower, or True Neocomien,	22	40
	Upper, or Urgonien,	18	
Aptien,			5
Albien,			11
Cénomanien			33
Turonien			42
Senonien			34

On comparing these numbers, it appears that the period of maximum, as to numerical development of species, is nearly the same in the brachiopoda, the inhabitants of deep seas, and in the lamellibranchiata, or coast mollusca, certainly a curious result. An examination also of the species in each stage is full of interest: of the twenty-two species found in the néocomien proper, twenty are peculiar to it, and therefore characteristic, whilst two species, rhynchonella lata and terebratula hippopus extend into the urgonien stage, having either lived within, or been drifted into it. Of the urgonien species fourteen are characteristic, two have appeared in the preceding stage, and two extend into the suc-

ceeding. In the Urgonien appears the first zone of a new series of animals, the rudistæ represented by eleven species of the genera caprinella, radiolites, requienia, and caprotina. In the Aptien stage there are only three characteristic species, two having appeared in the preceding. All the eleven Albien species are peculiar to it, and characteristic. The thirty-three species of the Cénomanien stage are also peculiar and characteristic; and here appears the second zone of rudistæ, which were entirely absent from the two preceding stages, being represented by seventeen species of the genera caprina, caprinella, radiolites, caprotina, requienia. The forty-two species of the Turonien are also peculiar to that stage; and the third zone of rudistæ is composed of no less than thirty-five species of the genera hippurites, caprina, caprinula, radiolites, biradiolites, and requienia. Of the thirty-four species of the Senonien stage all are characteristic; but the rudistæ, so numerous in the last stage, are now represented by only ten species of the genera hippurites and radiolites. The rudistæ were accumulated in banks, like our oysters, and must, therefore, have materially influenced geological formations. I shall hereafter discuss the merits of the geological divisions of M. D'Orbigny, in which the principle of nomenclature introduced by Sir R. Murchison, in his *Silurian* system, has been so freely adopted. But I may here remark, that the specific distinctness of the several stages of the chalk formation in the brachiopoda is very striking; and should it be supported by all other classes of animals, would justify him in the rigid conclusions he draws from this and some preceding classes, namely—

"1. The limits between the faunæ of successive formations are strictly defined, as none of the species of brachiopoda of the jurassic or oolitic formation pass into the chalk.

"2. There are distinct genera, as well as distinct species, peculiar to each great zoological epoch.

"3. These changes of forms in successive faunæ are the more marked as the epochs are more important. The generic differences are greater between the oolitic and chalk formations than between the several stages of the chalk.

"4. Though between the several cretaceous stages there are affinities, yet each possesses either its peculiar genera or distinctive groups of species.

"5. The species of brachiopoda are, with a slight exception (about one per cent.), peculiar to particular stages, of which they are, therefore, characteristic, under all forms of mineral deposit.

"6. No transition being observable between specific forms, these animals appear to have succeeded each other on the surface of the globe, not by passage, but by extinction of the races existing at one epoch, and the complete, or almost complete, renewal of species at each successive geological epoch."

I shall only cite one more illustration from this great work, and I shall take it from the cephalopoda. The nautiloid type of cephalopoda, in which the chambers are separated by simple septa, appears amongst the forms of the earliest known fauna of the earth; and it is remarkable, that at that early epoch this type attained its highest development, and underwent every possible variation as to external form—so that there were in the Silurian fauna, straight nautili, or orthoceræ; obliquely curved nautili, such as phragmoceras and cyrtoceras; open and regularly curved, such as lituites; and though some of these abnormal forms continued on to the Devonian, and even to the carboniferous strata, they were, on the whole, upon the decrement, and quickly ceased, whilst the normal or simple form of nautilus continued on to the existing epoch. The ammonoid type, in which the septa are foliaceous, did not, on the contrary, appear till a much later epoch, for though the simple form of septum was departed from in the goniatites of the carboniferous strata, the distinctly foliaceous septum first appeared in the muschelkalk or in the trias. In the oolitic formation, the normal form, in which the volutions are all symmetrical to one plane, and are either contiguous or enveloping, is preserved through a great number of species, which differ in other respects materially from each other; but, at the same time, a deviation from the normal form begins to occur, the curious genus Turrilites appearing in the Sinémurien, or lowest of the ten stages into which M. D'Orbigny divides the jurassic or oolitic formations, and the genera Ancyloceras, Toxoceras, and Helicoceras in the Bajocien, or fourth stage; and it must be also observed, that the presence of most of those genera in the oolitic formation has only been recently established. It is, however, in the cretaceous formation that the type of ammonidæ undergoes the greatest variation, and exhibits almost every possible divergence from the normal form in the

genera Crioceras, Toxoceras, Scaphites, Hamites, Ptychoceras, Baculites (or straight ammonites), Turrilites, Helicoceras, several of which will recall similar variations on the normal form of the nautilidæ in the Silurian epoch ; and, in like manner, after this great exhibition of the power of creative intelligence in adapting the shapes of other shells to the habitations of cephalopodous mollusca, the type not merely dwindled back into a simple form, like the nautilidæ, but in this case totally disappeared. Independently of its zoological interest, the course of development of the ammonidæ, when compared with that of the nautilidæ, seems to me a strong reason for believing that we do not see in the nautilidæ of the Silurian epoch the earliest cephalopoda of that type, and that there were organic stages, or faunæ, the traces of which we shall yet discover, if they have not been obliterated by metamorphic action. M. D'Orbigny distributes the cephalopoda of the jurassic system amongst the following ten stages :—

1. Sinémurien (sinémurium, or Semur)	35	species.
2. Triasic (adopting the English name)	41	„
3. Toarcien (Toarcium, or Thouars)	60	„
4. Bajocien (Bajoce or Bayeux)	53	„
5. Bathonien (from Bath)	20	„
6. Callovien (Calloviensis or Kelloway)	67	„
7. Oxfordien (from Oxford)	69	„
8. Corallien (calcaire corallien of Thurmann —Nerinæan limestone),	8	„
9. Kimméridgien (from Kimmeridge)	16	„
10. Portlandien (from Portland)	8	„
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And it is very remarkable that the ammonidæ, which formed a large portion of the great members of the sixth and seventh stages, were all belonging to the normal form, or genus ammonites. Of the above, all the species of the first, second, and third are characteristic, or as yet known only in their respective stages. Of the fifty-three species of the fourth, one is doubtful as to position, and specially belongs to the next stage. Of the twenty

species of the fifth, sixteen are characteristic, one is doubtful, and three occur in the sixth. Of sixty-seven species in the sixth, sixty-one are characteristic, three appeared in the preceding, and three extend into the following stage. Of the Oxfordian, or seventh stage, sixty-five species are characteristic, three have been cited in the preceding, and one occurs in the succeeding stage. In the Coralline, or eighth stage, there are only five characteristic species, two having occurred in the Oxfordian, and one extending into the Kimmeridge. Of the ninth, or Kimmeridge cephalopoda, fourteen species are characteristic, and two appeared in preceding strata. The eight species of the tenth, or Portland stage, are all characteristic.

In the fifth, or Bath, and the eighth, or Coralline stage, there is a remarkable disproportion between the number of species of cephalopoda and that of other classes, the total number of species in the Bath stage being 532, while that of the cephalapoda is only 20, and the numbers in the coralline being respectively 638 and 8. This curious disproportion M. D'Orbigny explains, by referring to the very few points of the ancient geological shore of France of these epochs, on a level with floating bodies which have been noticed, and adds, "they are, as it were, fragments of ancient coasts, on which have been deposited some remains of those floating bodies which then swarmed in the seas of those epochs." M. D'Orbigny, who believes in a more rigid limitation of zoological epochs than some other geologists, states, in conclusion, that in nine successive faunæ the cephalopoda were renewed by distinct forms or species; and in respect to the small number of species which occur in more than one stage, he considers that their presence does not prove that they existed at more than one epoch, as it may in most cases be accounted for on the principle of drift. It is, indeed, astonishing that bodies that are almost always buoyant, sometimes even when in a fossil state (a specimen of Ammonites cordatus having remained so after twelve stages of time), should not be found in greater numbers at various successive epochs. In estimating, indeed, the magnitude and zoological proportions of any fauna, it is necessary to exclude from it all those species which may have been derived from a pre-existing fauna by drift. In respect to the Devonian I have on a former

occasion enforced this rule; and there can be no doubt that in proportion to the number of manifestly drift beds, such as conglomerates and sandstones, in any formation, is the necessity of strictly adhering to it increased. It may, indeed, be assumed, that only those bodies can be deemed true members of the fauna contemporaneous with the drift which are either in such a condition as negatives the supposition of transport by drift, or are found under circumstances corresponding with their natural habitats, or though apparently drifted have never been observed in preceding formations, and may therefore have lived contemporaneously with, though distant from, the other members of the drift fauna.

Mr. Thomas Davidson* has carefully examined the species described by Valenciennes, in "Lamarcks Animaux sans Vertèbres" (1819), under the genus Terebratula, and gives figures of them all. These typical species are either in the museum of the Garden of Plants, or in that of Baron Benjamin Delessert, who is the present proprietor of the private museum of Lamarck, and were most liberally lent to Mr. Davidson. Such an examination as Mr. Davidson has thus effected is of the greatest value, both in settling the history of paleontological discovery and in clearing up that confusion which is so often the result of reference to species which are only imperfectly known by verbal description. He has also pointed out some few mistakes of M. D'Orbigny in the nomenclature of difficult species of terebratulidæ, and when the immense magnitude of the works which M. D'Orbigny has undertaken is contemplated, it may be considered praise that so few errors have been pointed out in the brachiopoda. As regards, however, the "Prodrome de Palèontologie Stratigraphique Universelle," and its accompanying work, "Cours Elementaire de Palèontologie et de Géologie Stratigraphique," in which M. D'Orbigny informs us, that "*all questions relating to geological generalities are fully treated, both as regards France and that portion of the world which is at present known to geologists,*" I cannot but fear that ample evidence will be found, in many defects, that such works are beyond the powers of any one individual. In the "Prodrome," for example, I cannot think that Crustacea, especially

* Annals and Magazine of Natural History. June, 1850.

the trilobites, exhibit a complete digest of all which had been done in investigating and describing that remarkable family, in which there is a development round a centre similar to that which I have pointed out in the nautilidæ and ammonidæ amongst the cephalopoda.

Mr. Thomas Davidson, in a second paper, describes and figures the internal calcareous supports of the ciliated arms of Terebratula pulchella (Nillson), and Ter. pectunculoides (Schlotheim), and also describes and figures Ter. Deslongchampsii (Davidson), a new species. He adds that it is his intention to publish shortly some views relating to the internal apophysary arrangements of Terebratula and allied genera, when doubtless he will enter into the general question of the subdivision of genera.

In the "Annales des Sciences Naturalles" of 1848, Messrs. H. Milne Edwards and Jules Haime commenced an elaborate history of "Polypiers," or of the hard, ossified, or stony parts of the bodies of polyps, and have continued it in the successive numbers of that most valuable journal. The same authors have since commenced a monograph of the British fossil corals, the first* part of which, containing the corals of the tertiary and cretaceous formations, has now been published. For the present I shall merely refer to the introduction, as it explains the general views of the authors on a class of animals so interesting both to the zoologist and geologist. Without dwelling on previous systems, I may observe, that Messrs. Milne Edwards and Jules Haime ascribe to the type of zoophytes the rank of a subkingdom, and divide it into two natural groups, one of which comprises all true radiate animals—echinodermæ, acalephæ, and polypi; the other, the spheroidal or amorphous zoophytes, spongidæ and certain infusoria.

In respect to this first step of classification, it certainly appears to me very desirable always to separate into a distinct branch those animals which are developed, as it were, round some typical centre, as we obtain thereby a much clearer view of the principles of organic creation, than by attempting to blend all animals into one general system. Of the radiate section, then, of zoophytes,

* Publications of Palæontological Society. 1850.

the class polypi forms the subject of our present consideration. Our authors agree with Mr. Dana in dividing the polypi into two sub-classes, Corollaria (the Actinoidea of Dana) and Hydraria (the Sertularian Polypi). The Corollaria are provided with a corallum or polypidom, by which terms are designated the hard or ossified parts of the body of a polyp, the corallum being in general calcareous and of various forms, such as tubular, cyathoid, discoidal, or basal. The corollaria are then divided into three groups or orders Zoantharia, Alcyonaria, and Podaetinaria. Of these the last, represented only by the genus Lucernaria, appears very aberrant from the normal type, as the polyp is not coralligenous, and though the gastric cavity is surrounded by four vertical membranaceous septa, the tentacula are pedunculated and discoidal, being organised much in the same way as in echinoderma, into which class it almost appears to pass as a simple or rudimentary form. The zoantharia are in general coralligenous, and include the polyps of almost all the known fossil polypidoms, so that the order is of the highest geological importance, the knowledge of ancient zoophytes being necessarily limited to that of their hard or stony polypidoms. One great peculiarity in this order is that each individual corallum which incloses more or less completely the inferior portion of the visceral or gastric cavity of the polyp has in general the form of a deep cup or a tubular sheath, the cavity of which is subdivided into a circle of loculi, by vertical septa affecting a radiate disposition; and the star-like appearance of calice thus produced is one of the most striking features of this zoological type. The hardened tissue of polypi is called by our authors, sclerenchyma; and the zoantharia are divided into two branches, according as this hardened tissue is present or absent, the sclerenchymatous, and the malacodermous or soft-skinned. The sclerenchymatous of former worlds can alone be studied by the Palæontologist, though it must not be concluded that none of the soft skinned were contemporaneous inhabitants of ancient seas. Of the sclerenchymatous Zoantharia, five sub-orders are distinguished as Zoantharia aporosa, Z. perforata, Z. tabulata, Z. rugosa, Z. cauliculata. The Z. aporosa are the most lamelliferous and stelliform of all the corollaria, are very numerous, and belong

to four principal and well-known families, the turbinolidæ, the oculinidæ, the astreidæ, and the fungidæ. In all these the corallum is essentially composed of lamellar dermic sclerenchyma; the walls are very seldom porous, and usually constitute an uninterrupted theca, so as not to admit of any communication between the visceral chamber and the exterior except by the calice; the septa are highly developed, completely lamellar, and primitively composed of six elements. There are no tabulæ or transverse horizontal septa, so that the visceral chamber remains open from top to bottom, or is only interrupted by irregular dissepiments which extend from one vertical septum to another, without joining together, so as to form a distinct discoid floor. In the turbinolidæ there are twenty-six genera, including Dasmia, which forms the aberrant group Pseudoturbinolidæ. Of these Cyathina and the various modifications of the cyathine type constitute the tribe Cyathinidæ, and Turbinolia and nine other genera Turbinolidæ. In the Oculinidæ there are Oculina and thirteen other genera, besides four genera of the aberrant group Pseudoculinidæ. In the Astreidæ there are seventy-nine genera besides Echinopora, which constitutes the aberrant group Pseudastreidæ, and Merulina, which forms a transitional group Pseudofungidæ. This great accumulation of genera is distributed into two tribes—the Eusmilinæ, in which the septa are completely developed and entire, their apical margin being neither lobate nor denticulate, the costæ are always unarmed, and the columella is often compact, or even styliform; and the Astreinæ, in which the septa have their upper edge lobulated, dentate, or spinous, and often imperfect near their inner edge, the costæ also spinulous, dentate, or crenulate, but never forming simple cristæ, and the columella in general spongy, rarely lamellar and never styliform, corallum in general massive. These tribes are further divided into many sections, but for the present it is only necessary to say, that amongst the Astreinæ we meet the well-known genera, either recent or fossil, Caryophyllia, Calamophyllia, Meandrina, Astrea. In the Fungidæ there are twenty-three genera, divided into three tribes, one of which includes the genus Fungia, and is called Funginæ. The next sub-order is that of Zoantharia perforata,

in which the sclerenchyma or coralline mass is, instead of being formed of imperforated lamellæ, always porous, or even reticulate. The walls which constitute the greater mass of the corallum do not consist of laminæ, are always perforated, and completely or nearly naked. The visceral chamber is almost completely open from top to bottom, and never filled up with dissepiments or with tabulæ. The madreporidæ form a family in this sub-order, including the genus madrepora. The number of genera in the sub-order is twenty-five.

The third sub-order, Zoantharia tabulata, is distinguished especially by the existence of lamellar diaphragms, which form complete horizontal divisions extending from side to side of the general cavity; the septa are more or less rudimentary, but are arranged in the same mode as in the preceding divisions. There are four families—Milleporidæ, containing eight genera, amongst which are millepora, and heliopora, and fistulipora a new genus founded by Mr. Frederick M'Coy; Favositidæ, comprising eleven genera, which include favósites or calamopora of Goldfuss, and halysites or catenipora of Lamarck; Seriatoporidæ, comprising three genera, of which seriatopora is one; and Thecidæ, consisting of one genus.

The fourth sub-order, Zoantharia rugosa, is distinguished by a different septal arrangement than that of the preceding, the primary number being four and not six, so that the calice assumes a crucial appearance. Or when true septal groups cannot be discovered, they are represented by numerous equally developed radiate striæ on the surface of the tabulæ which extend up the inner side of the walls; the corallites are always distinct, the septa are never porous, and the visceral chamber is in general filled up from the bottom by a series of transverse tabulæ, or by a vesicular structure, which often constitutes the principal part of the corallum. In the thirty-six genera of this sub-order occur amplexus coralloides (of Sowerby), cyathophyllum helianthoides (of Goldfuss), campophyllum or cyathophyllum flexuosum (of Goldfuss), strombodes, lithodendron, and lithostrotion. Three genera are added as uncertain Zoantharia, of which one is Mr. M'Coy's heterophyllia.

The peculiarities in the substance of the walls of the corallum were pointed out by Mr. Lonsdale, and they became important aids in classification, and the presence or absence of transverse tabulæ is also highly discriminating. I will not at present dwell

at length on the order Alcyonaria, though highly important both to the recent and fossil zoologist, and marked by great differences of form; Tubipora, Alcyonium, Gorgonia, Pennatula, are all well known, and types of families strongly separated from each other. In Gorgonidæ is the Corallium rubrum, or red coral of the Mediterranean, and in Pennatulidæ the genus Graptolithus, so characteristic of the Silurian system. Of the other two orders it is unnecessary to speak, as they have no bearing on geological science.

In applying the principles of this zoological classification to the geology of England, our authors begin with that very remarkable formation, the crag; and show that, separating Bryozoa, there are really very few true corals either in the red crag or coralline crag; and, in fact, that four species, mentioned by Mr. Searles Wood, in his Catalogue of 1844, are the only known polypidoms of the division. They belong to four distinct genera, each of which is represented by species in the other miocene formations, and none of which have been discovered in strata anterior to the elder tertiaries. Three of the genera are also represented by peculiar species in the actual fauna.

The corals of the London clay are more numerous, embracing a greater range of families and genera. None are considered specifically identical with those now living, or even with those found in the more recent tertiaries. Some species are common to the London clay and the "calcaire grossier' of the Paris basin; but most of the Paris eocene corals have not been found in the London clay, and many of those belonging to the latter have not been found elsewhere. These difficulties are explained as the results of peculiarity of habitat, the corals of the London basin generally resembling those of very deep water and of a loose muddy or sandy bottom; whilst those of the Paris basin are more like the inhabitants of rocky shores and shallow water. The total specific distinction between the corals of the London clay and those of existing seas, is a very remarkable fact, and proves, with many others, that the successive faunæ of the earth are not the results of partial modifications, but of complete renewal. It might be possible to conceive partial changes of the higher animals, and yet a continuation, as a sort of ground-work, of the great mass of the fauna; but when the change affects the lower as well as the higher, no partial modification can explain it.

There are very few species of coral in the upper chalk, and still less in the lower chalk; and it is remarkable that, in all probability, most of those found in England are peculiar to the British seas of that epoch. In the upper green sand corals are also few in species: in the Gault they are more numerous; but in the lower green sand they are again extremely rare, our authors having only met with one decided species, and that belonging to the great division of Zoantharia rugosa (so predominant in palæozoic formations), of which it is the most modern representative. This almost dying away of true corals in the most recent secondary and in the tertiary formations—the type of Zoantharia rugosa, so prevalent in older formations, only struggling on to the lower green sand—deserves especial attention, as another proof that successive faunæ indicate total and not partial changes in organic systems.

In noticing thus briefly this most important work of Messrs. Edwards and Haime, I have frequently cited the name of Mr. Frederick M'Coy; and I cannot but express my gratification that this young naturalist, who is one of ourselves, and commenced his labours in Irish palæontology, has, by steady perseverance and great ability in the examination and description of the fossils of the Woodwardian (which may now be termed the Sedgwickian) Museum, at Cambridge, laid the foundation of a great name amongst palæontologists. Mr. M'Coy now occupies the chair of Geology in the Queen's College at Belfast; and I would suggest to him and our active member, Mr. M'Adam, how much good might be done by their co-operation in working out the palæontology of the northern chalk and other formations.

The work of Messrs. Edwards and Haime is due to the Palæontographical Society, and adds to its claims on the gratitude of geologists; indeed, can it be possible to estimate too highly works proceeding from Professor Owen, Mr Searles Wood, the authors on whom we have been commenting, and others. The Monograph of Permian Fossils, by Mr. King, is one of these most important works, as it establishes fully the claim of the Permian strata, first separated as such by Sir R. J. Murcheson, to be admitted as records of a great geological epoch. The general evidence induces me, however, still to connect the Permian with the protozoic formations, and the trias with the

deuterozoic. M. Adolphe Brongniart has also shown that much caution is required in determining what strata should be really included under this denomination, the flora of the bituminous and cupreous schists of the Mansfeld Zechstein, and that of the Permian sandstones of Russia, exhibiting a widely different list of species, no species common to both having yet been discovered—a fact which naturally leads to the inquiry, whether so great a difference only marks distant local floræ, or is due to the effect of difference of epoch, such as is observed even in animals in the subdivisions of the oolitic and cretaceous formations.

Before I quit this branch of my subject, let me congratulate the Society on the efforts which the University of Dublin is making to extend and improve the Natural History Department of its Museum under the superintendence of our able Vice-President, Robert Ball. The beautiful series of antlers of the Great *Irish Elk* (as it is so commonly called), which exhibits the increase by age from the smallest to the most mature condition, is very remarkable, and, certainly, as yet unrivalled. The exertion too in palæontology of the Geological Survey, both in England and Ireland, correspond to the high scientific character of Professor Forbes, who directs that branch of a work conducted in chief by Sir Henry De la Beche. In Ireland the labours in the field have been productive of the most important palæontological results, as may be estimated by the fact kindly communicated to me by the present able local director, Mr. Jukes, that since 1835, when I first made known the existence of Silurian strata in Ireland, no less than sixty-nine new localities have been discovered by the Geological Survey. My localities were limited to Tyrone and Fermanagh, whilst these extend into Meath, Louth, Dublin, Kildare, Wexford, and Waterford; being most of them traced out in the field under the several directors, by my former zealous and most successful assistant, Mr. James Flanagan. The speedy publication of such treasure is much to be desired, and I could hope that Professor Forbes will call to his aid for such an object the talents of Mr. M'Coy. I feel that exhaustless as this subject is, I must now cease, and in doing so, I will only trust that I have not entirely failed in my effort to set before you the leading features of geological science. Never, indeed, has geology stood on so sound and exalted a basis as it now occupies, when every collateral science

is brought to bear on and illustrate it. The mathematician applies the resources of profound analysis to explain its phenomena, and the experimentalist aids by testing and repeating in the laboratory the processes which, on the grander scale, are exhibited by nature in the interior of the earth. There are, indeed, two distinct modes of advancing geological science, namely, by observing the facts of nature, separating, distinguishing, and classifying them, as has been done by M. Elie de Beaumont, in his Essays on Mountain Chains; or, secondly, by tracing experimentally the mode in which such great phenomena have been produced, as has been done so ably by Mr. Mallett. Then, again, Mr. Faraday has, by his beautiful discovery of a distinction between magnetism and diamagnetism, or as he calls it, between paramagnetism and diamagnetism, opened a way to the mysteries of cohesion and repulsion, and we seem to feel that by a change in these conditions of matter, and its effect on the cohesion or the fluidity of matter, the stability of the earth may at any time be disturbed, and its strata thrown into confusion. And, finally, the philosophical inquiries and reasonings of the palæontologist have unfolded to us the records of past organic worlds, and enabled us to trace fresh proofs of the wisdom of their Great Creator in each renewed exercise of his will and power.

Let us then, my friends, endeavour to show that we are deeply impressed with the real dignity and practical value of our science, and strive to keep in the advance rank of its most assiduous admirers and cultivators.

J. E. PORTLOCK.

[After the delivery of my Address, Mr. Mallett, who was unable to attend at the Anniversary Meeting, intimated to me that he thought that I and others had misunderstood the enunciation of his theory. I have endeavoured to represent it as I conceived it to have been delivered originally by its author; but he now states that he intended to extend the principle of slips to detrital matter under water. At my next address I will notice the peculiarities of this enlarged view of the theory; but I must here observe, that no verbal statements to a society, unless they have been reduced to writing, and in some form or other made a permanent record, can be received in justification of a claim of priority. Were a different principle adopted, any vague perception, such as often floats in the mind of every ingenious man, would be put forward, and stand as a warning against the efforts of other inquirers, until its author had leisure to mature his ideas, and determine whether his theory could be established by an appeal to facts and nature.]

November 18, 1850.—"Notice of Scratches upon the Rocks of Bantry Bay, and of some intrusions of Igneous Rocks amongst the Schists, and consequent disturbance of the strata;" by Lieut.-Col. Portlock, R.E., President.

In my passage to Whiddy Island, from Glengarriff, I was struck by the appearance of a bluff head-land of boulder clay on the main shore, and landed to examine it. It appears to be a portion of a great mass or bed, which, probably extended continuously over the inner portion of the bay, namely, the part which lies between Whiddy Island and Bantry, as many similar bluffs are observable at other points. On landing, I found that the schists exhibited ragged, projecting edges, where exposed to the free action of the sea; but walking over them towards the clay bluff, which was partially retired from the water's edge, I first found an edging of shingle, proceeding apparently from the wear of boulders which had fallen out of the clay, and then observed a portion of the rock at the very base of the cliff worn quite smooth and round, and, in a degree, polished. On this I noticed many very fine scratches, which had a partial parallelism, though occasionally affected in directions by the changes in the angles of the plane surfaces. It appeared to me that these scratches passed under the clay; and my impression is, that the whole mass must have moved onwards, and that the pebbles which produced the scratches were imbedded in the clay. The polishing of the rock itself may, however, have been the previous result of the passing over it of looser and finer materials, such as sand, as it seems difficult to attribute such an effect to any very slow movement of a boulder clay.

In further examining the schists, I found that they were penetrated by veins of igneous rocks, which seemed to have been protruded between the beds; and, on crossing to Whiddy Island, I found a most beautiful example of physical disturbance, probably due to such protrusion, in the counterscarp or side of the ditch of the East Fort. The contortions are of the most striking kind, as exhibited in the accompanying drawing, made for me by Mr. Murphy, the engineer contractor; and connected with them

is a curious instance of metamorphic change. The schists are here the carboniferous slates of Griffiths, but they are very much indurated and changed in physical characters, and exhibit a curious bed of lenticular nodules, or masses, some of which are three or four feet long, which follows the contortions of the other beds. Some of these have fallen out, and the cavities they have left are, on their sides, quite smooth, and almost polished. They are hard, and appear to the eye so like some trap rocks, that my first idea was to connect them with the rocks of intrusion, The analysis, however, undertaken, very kindly, by the Rev. Mr. Galbraith, dispels such a notion, and renders it evident that they were either calcareous nodules so common in shales, or parts of a calcareous bed, which had separated, under metamorphic action and contortion, into lenticular and independent masses.

The analysis is appended, and is remarkable from the great quantity of manganese. Whether this was original, or, together with the magnesia, was derived from the adjacent strata at the time of physical change, there can be little doubt that to its presence, and that of the silica, must be ascribed the peculiar mineral characters of the nodules, which in appearance assimilates them to igneous rocks,

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December 11, 1850.—"Analysis of a Nodule found in the Slate Rock of Whiddy Island, Bantry Bay;" by the Rev. JOSEPH A. GALBRAITH, Fellow of Trinity College.

CaO, CO_2	=	86·30
MnO, CO_2	=	3·44
MgO, CO_2	=	1·04
Silica, &c.	=	8·21
Water and loss,	=	1·01
		100·00

Besides these constituents there appeared traces of iron and alumina; but, as the quantities appeared inconsiderable, I did not estimate them separately. They were precipitated with the manganese, which, for that reason, will appear a little in excess.

Specific gravity = 2·709.

March 12, 1851.—"Notice of the occurrence of fragments of Granite in Limestone, County Dublin;" by the Rev. SAMUEL HAUGHTON, Fellow of Trinity College, Dublin.

THE quarry in which this phenomenon was first noticed is situated near Crumlin, Co. Dublin, a short distance from the road leading to Crumlin from Roundtown. The fragments of granite occur in only one bed of limestone, varying from six to twenty inches in thickness. The beds of the quarry have an inclination of 20° to 18°, which is very constant throughout the quarry. The dip is S. 23° W. (magnetic,) and does not alter sensibly in the portion of the beds which is exposed.

The bed in which the granite is found has been quarried through an extent of about sixty square feet. The fragments are pretty uniformly distributed through the whole of the bed which is exposed, and vary in size from about eight inches in diameter to the size of small grains of gravel.

The granite which is exposed in the neighbourhood of joints of the limestone is partially decomposed, and the felspar in some places replaced by crystals of carbonate of lime. It effervesces with acids, in consequence of the infiltration of carbonate of lime, from the surrounding limestone.

The fragments of granite are angular, and do not appear to have been rolled about by the action of the water. The nearest granite in situ is at least four miles distant, near Killikee, which lies nearly south of the quarry.

The most interesting fact connected with the occurrence of these granite fragments is the well-ascertained fact that they occur in only one thin bed; proving clearly that the causes which produced them did not operate continuously, but acted for a time and then ceased.

The other specimen of imbedded fragments of granite was procured by Mr. Greenwood Pim from Monkstown, close to the church, and appears to have been taken from the neighbouring gravel pit. It is a rolled boulder of limestone, and contains fragments of slate as well as of granite.

On examination it proved to be a *Dolomite*. It is highly crystalline and fossiliferous. Its analysis is as follows:—

MgO, CO_2	= 34·82	per cent.	·81 atoms.
CaO, CO_2	= 48·24	„	·96 „
FeO, CO_2	= 1·40	„	·02 „
Argil,	= 14·64	„	
	99·10		

This analysis may be approximately represented by the formula,

$$7\,(CaO,\ CO_2) + 6\left\{(MgO, FeO)\ CO_2\right\}$$

The following analysis of the Dolomite occurring between Williamstown and the Rock station of the Kingstown Railway, is added, to show that the boulder of limestone above described did not come from that locality:—

Argil,	= 15·66	per cent.	
FeO, CO_2	= 11·89	„	·205 atoms.
CaO, CO_2	= 47·21	„	·944 „
MgO, CO_2	= 25·64	„	·600 „
	100·40		

Giving an approximate formula for this Dolomite—

$$7\left\{CaO,\ CO_2\right\} + 6\left\{(MgO,\ FeO)\ CO_2\right\}$$

April 9, 1851.—"On the Geology of the South Staffordshire Coalfield;" by J. Beete Jukes, Esq. M.A., F.G.S.

Mr. Jukes commenced by giving a sketch of the geological structure of part of the midland counties of England. He briefly described the position of the carboniferous rocks of the great Penine chain, and the way in which they plunged beneath the great plain of the new red sandstone, their reappearance from under that formation, on the flanks of the mountains of North Wales, and in the coalfields of Bristol and South Wales. He then drew attention to the island-like coalfields of the midland counties—Leicestershire, Warwickshire, Staffordshire, and Shropshire; and showed that in this latter district the lower part of the great carboniferous formation, namely, the mountain limestone and millstone grit, and, also, the old red sandstone or Devonian

rocks, were almost entirely wanting, and the upper part of the "coal measures" rested directly on rocks of silurian or still earlier date.

He then proceeded to describe, in rather more detail, one of the most interesting of these isolated coalfields, that of South Staffordshire, of which Dudley might be considered as the centre.

This district is composed of rocks belonging to three geological formations.—1st. New red sandstone. 2nd. Carboniferous. 3rd. Silurian.

The silurian formation is here composed almost entirely of soft shale, locally called "bavin." It contains near the top a band of impure argillaceous nodular limestone, about twenty-five feet thick, referrible to the Aymestrey limestone of Sir R. Murchison, about 1,000 feet below which is the Wenlock and Dudley limestone, generally composed here of two bands about thirty or forty feet each. About 1,500 feet below this is another band of limestone, locally called the Barr limestone, which is likewise about twenty or thirty feet thick, and which, probably, is the same as the Woolhope limestone of Sir R. Murchison. Below this, again, but at an unknown depth, the top of the Caradoc sandstone appears in one part of the district.

The carboniferous formation consists entirely of true coal measures, having no representatives of the mountain limestone or millstone grit. Its maximum thickness is probably about 1,500 feet. Its upper portion is comparatively barren of good coal or ironstone, but in its centre and lower parts it is remarkably rich, it having in one part an assemblage of beds of coal, resting one upon the other, till they make a solid mass of coal, about thirty feet in thickness. This thick or ten-yard coal is generally made up of about twelve beds. It has, however, many changes and variations. In the south part of the district, about Stourbridge, some of its beds become worthless, and it is then considered as three coals. In the northern part it is divided by beds of shale and sandstone into many beds, which are not at all looked on generally as part of the thick coal. In the richest part of the district—about Bilston, namely,—the following is the normal section:—

Broach coal, and ironstone. Thick coal, Gubbin ironstone. Heathen coal, New mine ironstone. New mine coal. Fire clay coal, Poor Robin's ironstone. Bottom coal, Gubbin and Balls ironstone. Blue flats ironstone.	**Total thickness about 500 feet or 170 yards.**

As we go south, however, the coals and ironstones in the lower part of this section gradually deteriorate, and south of Dudley nothing is worked below the heathen coals. At the extreme northern end of the field again there are fifteen coals in a distance of about 600 feet, only one or two of which are four feet thick; there is little or no ironstone, and as the workings are quite isolated, it is at present impossible to bring them into co-relation with the southern part of the field.

The new red sandstone is composed in this district principally of red sandstones, and conglomerates with an occasional band of marl, and in one part of the section there are one or more bands of impure calcareous sandstone, resembling the cornstone of the old red sandstone, or a calcareous conglomerate of pebbles derived from the mountain limestone. Many of the conglomerates are quite soft and incoherent, and under the name of gravel, have been confounded with the superficial drift of the country.

Besides these stratified rocks there are two kinds of igneous rock in the district. 1st. An old trap, an imperfectly formed syenite or porphyry, which is probably of silurian age, and which is seen only in the Clent Hills, in the extreme southern part of the district; the second is a basalt, of an age subsequent to the formation of the coal measures, which bursts through them at several places in the central portion of the coalfield in large masses, and burrows among them in great sheets over several square miles. This basalt in some places passes into a highly crystalline porphyritic greenstone, and in others (especially in its diverging dykes and veins), into a white feldspathic trap.

Such being the constitution of the rocks, their relations to each other are as follow :—

The new red sandstone on the southern border of the field seems to repose conformably on the upper part of the coal measures; there are, however, no beds of passage as there are beds of conglomerate at the base of the new red containing pebbles of coal, &c. Both formations are nearly horizontal, and, therefore, they of course appear conformable. Along both the east and west margins of the coalfield the new red is brought down against the coal measures by great down-throw faults, while along the extreme north edge of the field, the new red rests distinctly unconformably on the edges of the coals, which are worked beneath it, and crop gently up into it.

In like manner the coal measures appear at first sight to be conformable to the silurian, but are found really not to be so. When greatly broken by faults, or tilted up at great angles, both formations appear equally affected, but on the west side of the field the coal measures rest on the uppermost beds of the silurian, while on the east they repose on beds much lower, being the Aymestrey limestone in the one case, in the other the Dudley. Moreover in the cutting of railroads, cliffs of Silurian were seen with coal measures abutting against them and containing beds of pebbles; and near Walsall the lower part of the coal measures overlaps the limestone, so that it is evident the Silurian had a dip to west, and its edges were denuded before the coal measures were deposited on it, although the dip was so gentle as not to differ in any one spot more from the horizontal than the coal measures did when first deposited. Mr. Jukes then proceeded to describe the remarkable examples of unconformability of all these rocks at Lord Dartmouth's pits. He first of all, however, gave a short description of "rock faults," which are curious masses or cakes of sandstone that take the place more or less entirely of the thick coal in certain localities, and he showed that Lord Dartmouth's pits exhibited a complicated example of unconformability combined with a rock fault.

While on the subject of exceptional structure in thick coal, he described the "flying red," especially that near Kingswinford, and mentioned the important bearing of these two facts on the question of the origin of coal.

Mr. Jukes then entered on the description of the internal struc-

ture of the coal field, describing the principal anticlinal axis, which runs N.N.W. and S.S.E., but is not continuous. It stretches from Sedgley to Dudley, forming a ridge with three centres of local intensity, which produce three oval dome-shaped elevations—Hurst Hill, Castle Hill, Wren's Nest. South of Dudley, the force causing elevation was relieved by the bursting through and overflowing of the trap of Rowley Hills; but it appears again farther south, in the Lickey, where there is an anticlinal axis of Caradoc sandstone, with Wenlock shale and coal measures on each flank. This axis divides the field into two portions. The south-west portion has one longitudinal fault parallel to the axis, a down-throw to west of 40 to 100 yards; and several cross faults bending more or less, and running from this to the western boundary fault. Also, one small anticlinal axis, running N. by E. and S. by W.

The central portion of the field has rather a trough-like structure, between the ridge of Dudley and Sedgley, and the high silurian ground of Walsall. This trough is traversed by numbers of east and west faults, which gradually end in each direction, and have their greatest throw in the centre. Starting from Rowley Hill, and going north, the faults first of all throw down to the north 40 or 50 yards each, up to the Dudley port trough faults, which cause a throw of 130 yards in coal, but do not affect the silurian; from this as we go north the faults throw up to north so as to make thick coal crop at Bilston, &c.; then the other beds rise gradually to the north, up to the Great Bentley fault, which throws down again to north and brings in the bottom part of the thick coal. Another similar great down-throw to west beyond Daw end, brings in the Aldridge coals.

North of these localities the dip of the coal field is generally west at a slight angle, so that the upper measures at Wyrley, are really on a parallel with the thick coal. These stretch off to the north, but not being worked, are very little known till we get to Brereton-Wyrley, Brereton, and Brown Hill, being the only well-known localities.

Mr. Jukes then entered into an explanation of "trough faults," and of the method of their formation, showing how it is they affect the upper and not the lower beds, &c.

He then made some remarks on the practical question of finding coal below the new red sandstone, showing the prudence of not undertaking the search without sound geological advice; he described

the probable thickness of new red sandstone as 300 or 400 yards at least, while its unconformability to the rocks below rendered it possible, after piercing it, to come down on any other of those rocks, instead of the true coal measures.

Mr. Jukes concluded by noticing a new discovery of some beds of lias on Needwood forest, made by himself in 1850, and noticed the probability, from the existence of lias here and in Cheshire, that all the midland counties were once a great lias plain, and that the great boundary faults of the coal fields, while certainly more recent than the red marls, may even be newer than the formation of the lias.

June 11, 1851.—Account of a new Mineral species. Communicated by JAMES APJOHN, M.D., Professor of Chemistry and Mineralogy, Trinity College, Dublin.

THE mineral which is the subject of the present notice was brought to Dublin last autumn, by the Rev. Professor Jellett, who purchased it, with several others, from a mineral dealer, whom he encountered in the valley of St. Nicholas, in Switzerland.* Suspecting it to be an undescribed species, he placed it in the hands of Dr. Apjohn, Professor of Mineralogy in the University, who, after an examination of its physical and pyrognostic characters, saw reason to adopt the opinion of Professor Jellett, and committed it to Mr. H. Wright, one of the most experienced of his laboratory pupils, with a request that he would make a careful analysis of it.

This mineral occurs as a partial incrustation, of a dull greenish yellow colour, on the surface of a stone which seems to be an indurated talc schist, containing imbedded brown granular garnets, and a little adhering white asbestus. In the fracture it is quite compact; but must, nevertheless, be considered as composed of numerous aggregated prisms, the rhombic bases of which, having angles of about 60° and 120°, are distinctly seen on the exterior of the incrustation, particularly when it is examined with a lens. Its hardness is over 7, or it is situate, in the scale of Mohs, between quartz and topaz, the former of which it scratches with facility. Specific gravity = 3·741. Heated alone by the inner flame of the blowpipe, it slags, acquires a dark colour, and is then

* Since the reading of this notice, Professor Jellett, who has just returned from another excursion into Switzerland, has shown me some good specimens of this mineral, which he picked up himself last August (1851), on the Moraine of the glacier of Findelen, in the immediate vicinity of Monte Rosa.

strongly attracted by a magnet. When in a fine powder, it is acted upon by muriatic acid, but does not gelatinize. The acid takes up lime and iron, the latter exclusively, as Fe_2, Cl_3, leaving an impure silex, so that the decomposition is not complete.

19·45 grains, submitted to analysis, gave—

Silex, ...	7·39	37·99
Peroxide of iron, . .	6·53	33·57
Lime, ...	5·76	29·61
	19·61	101·17

And a repetition of the analysis, 17·09 grains being operated upon, gave—

Silex, ...	6·51	38·09
Peroxide of iron, . .	5·71	33·41
Lime, ...	4·89	28·61
	17·11	100·11

The results of both analyses agree perfectly, and conduct to the same empirical formula, viz.:—

$$4\,Si\,O_3 + 2\,Fe_2\,O_3 + 5\,Ca\,O.$$

But how are these constituents grouped, or, in other words, what is the most probable rational formula to which they correspond? This is a question of some difficulty; for if we assume, as is usually the case, that the peroxide of iron discharges the basic function, we are compelled to admit the presence of such a silicate as $5\,Ca\,O,\ 2\,Si\,O_3$, that is, of a compound which has not hitherto been found as a distinct mineral, or been recognised as a proximate constituent of any compound silicate. Under these circumstances, it would probably be allowable to view the peroxide of iron as acting the part of an acid or electro-negative principle, (its isomorph alumina we know frequently performs such a part), which will enable us to write the formula—

$$2\,(Ca\,O, 2\,Si\,O_3) + 3\,Ca\,O, 2\,Fe_2\,O_3,$$

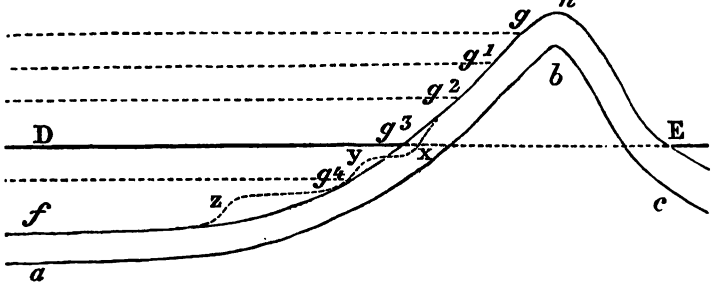
or to represent the mineral as composed of a bisilicate and subsesquiferrate of lime; compounds which have numerous analogies, and the possible existence of which may therefore be readily admitted.

This mineral, which is undoubtedly new, it is proposed to call Jellettite, after the distinguished mathematician through whose means it has been made the subject of chemical and mineralogical examination, and established as a distinct species.

June 11, 1851.—"Some remarks upon the Movements of Post-tertiary and other Discontinuous Masses;" by ROBERT MALLET, C. E., M.R.I.A.

SOME months ago, I believe about December last (1850), it may be in the recollection of the Society, that I addressed a letter to my friend, Professor Oldham, claiming priority of discovery with respect to certain views relative to the movements of detrital masses. That letter was, I believe, communicated to the Society at a meeting at which I was not present. In the last annual address in February, 1851, our President, Colonel Portlock, has impugned my claim to priority as respects the views affirmed by me in the above letter. I was unable to be present at the reading of that address, and as it is not yet printed, nor has any abstract of it appeared as usual in the newspapers or journals, I am unable to state from its words upon what authority Colonel Portlock relies for the contradiction which I understand him to have given to a claim to priority of discovery which I still deem well founded on my part.

But I have been furnished, in a private communication from Colonel Portlock, with the two authorities upon which he relies, and which I understand him to have quoted in that address; and as, on reference to these, neither of them appears to me at all to touch the question, and as I apprehend that the precise view, to the first promulgation of which amongst geologists I lay claim, seems to me (from this) to be still in some degree misconceived or forgotten, I beg to state, in two simple and distinct propositions, what this view is:—



It is commonly an admitted fact amongst all geologists, that the dry land, such as we now find it, consisting of a continuous rocky

skeleton, with a more or less complete covering of discontinuous or detrital matter over its lower portions, began to be elevated above the sea-level, with the rocky portion bearing still upon its face all that loose detrital mass which had formed upon the rocky bottom (by whatever means) while below the sea-level. A large portion of this detrital covering has been at some time, and in some way, *subsequently* removed.

First, then, if, in the above diagram, *a b c* represent the rocky skeleton of such land in progress of elevation above the sea level *D E*, and $f\ g^3\ h$, be the coating of discontinuous detrital matter elevated with it:—then I affirm, that one of the most important elements in the mechanism of motion by which this coating will be removed from the elevated land, or from its higher portions, and passed downwards into the plains, or farther again out into the sea, beneath the new or permanent horizon, will be the formation of successive parallel roads, bars, or beaches, as at the points g, g^1, g^2, g^3, g^4, assumed as successive lines of temporary coast line, and within the limits of wave and tidal action, and that successive slippages or slidings out, *en masse*, of loose material, such as sand, mud, gravel, or earth, often bearing large boulders, will continually take place along every such coast at the points marked x and y, at the steep taluses formed along them by the tidal or wave action; and that the distribution of the materials thus descending from above will again produce other similar slippages, at such points under water as those marked z; and that these occur on slopes (of supporting rock) of very moderate inclination, and produce upon the subjacent rock the phenomena of scratching and furrowing, rounding, &c., and in general simulate all the principal traces of glacier action, for which, and for evidence of a supposed arctic or glacial period I consider they have been frequently mistaken.

This subject, which has occupied my mind for some years, and the fundamental proposition of which, as above, was first broached by me to Professor John Phillips, as long ago as when he was Professor of Geology in the Dublin University, and was also publicly promulgated by me at the last Cambridge meeting of the British Association, in the section of Geology, when Professor Sedgwick was in the chair, in the discussion upon a paper by the Rev. J. Cumming, on the Traces of Drift Ice in the Isle of Man, on which occasion I first gave the name of "mud glaciers" to all such masses of slipping materials,

whether under water or above water,—is, I believe, one of importance, and pregnant with results of high value and interest to physical geology, and I trust to be able to complete my long intended task of laying a paper, fully developing my views upon the subject, before the Society when it meets again.

My second proposition is but a corollary to the first, namely—

That around all the existing coasts the formation of such masses of loose material, and their continuous or intermittent slippages, are in daily progress, and that the grooving and furrowing of rocks beneath is now taking place thereby, and the transport within such masses of large boulders detached from sea-cliffs, which are thus gradually transferred out into deep water, and often to vast distances over the floor of the ocean, whence they would emerge and be left isolated, if at a future time such floor should become dry land.

If these two propositions be true, it follows that the rock scratchings throughout the globe will be found hereafter to have been formed by, and to represent the resultant directions of descent of the vast masses of detritus thus moved over them,—moved not by any *debacle*, or by any process of *sweeping away*, surface by surface, or of *cutting* away by *current* action of water, which are the commonly received notions of denudation, but moved bodily and *en masse*, by a *vis a tergo*, namely, the weight of the mass itself, of loose material, acting as a semi-fluid or plastic body, bearing and carrying along with it included solids (boulders, stones, &c.).

These are the views to the origination of which I lay claim, here stated, however, in the most bare and unillustrated way. I have no intention of entering into their merits at present; whether they be true or false, valuable or valueless, is not the point for which I trespass upon the Society, but simply to re-assert my claim to be the originator of them.

I am unable to find any trace of such views as above stated, and as also stated in my letter, before referred to, of December last, in any geological author, and the two authors referred to by Colonel Portlock do not allude to the same subject at all.

The first is M'Culloch, in his System of Geology, vol. ii., p. 368, 369, on "Alluvia of Descent." A reference to this passage, taken in connexion with the whole of the preceding and following pages, on the subject of alluvia or diluvia, will prove to any candid reader,

that the author means by "alluvia of descent," alluvia transferred downwards, *particle by particle*, on slopes of *already elevated land, by the action of rain.* This passage, therefore, does not touch the question at issue, nor can I find a trace of a notion similar to mine (as already stated) throughout M'Culloch's work.

The other passage referred to is by Agassiz,* and is still further from the point—" Et l'on a prétendu que *des courans* de boue chargès de graviers pourraient seuls avoir produit de semblablés effets."

The author here is speaking of the possible causes, other than glaciers, of the scratching and grooving of rocks, and alludes to the passage of mud and gravel, *carried* over the surfaces of rocks by *currents* "*des courans*" *of water*, and he rejects these as a source of scratching altogether. He is, therefore, not speaking of the movement by slippage or sliding, *en masse*, of wet and plastic loose material, in virtue of its semi-fluid properties, but of solid matter *propelled* along by currents of water; and, moreover, he rejects the view he refers to, whatever it maybe, as a cause of scratching and grooving. Hence, neither does Agassiz touch the subject to which I lay claim.

These are the only two authorities quoted against me by Colonel Portlock, as I understand; and as both of these appear to me to fail in substantiating the slightest anticipation of my peculiar views, I must deem myself still their first originator; and while certain that Colonel Portlock would not knowingly deprive any fellow-labourer in science of whatever credit justly may belong to his investigations, I must regret that, upon an imperfect knowledge, apparently, of what the precise nature of my views were, he should have committed the formal weight of the passages before referred to in his presidential address, in denial of my right of priority of origination, upon grounds which really do not bear upon the matter at all.

APPENDIX.—EXTRACTED FROM THE MINUTES OF THE SOCIETY.

(No. 1.)

Minute of Wednesday, Nov. 12, 1845.

"Mr. Mallet then read an introductory notice on the movements of the gravel beds and of erratic boulders, in which he maintained that these movements were not due to any general diluvial wave or current, but to ordinary forces of water caused by elevation of the land."

* Etudes sur les Glaciers, First Edit., 1850, p. 196-197.

(No. 2.)

Mr. Mallet's Letter to Professor Oldham, communicated to the Society by Professor Oldham at the Meeting of the Society, Dec. 10, 1850.

"DUBLIN, *December* 7, 1850.

"MY DEAR SIR,—The increasing importance which geologists are beginning to attach to the movements of the loose material forming part of our earth's crust, and the identity of view, held and promulgated recently by many, as to one particular question relative to these movements, with those which I myself long since ventured to assert, but which have, I believe, not been very generally known, and certainly have been reproduced in several cases without acknowledgment or reference to the original author or discoverer, induce me, by the present communication, to take date, once for all, as to my own claim (whatever may be its value) to be the original discoverer and first publisher.

"In the latter end of May, 1844, you and I made a geological examination of some parts of the calp cuttings of the Drogheda Railway, in the neighbourhood of Killester. We observed numerous scratchings of the rock *in situ*, and of the lower surfaces of boulder masses, imbedded in the clay and gravel beds above it. I pointed out to you on the spot the evidence that led me to conclude that much of the superincumbent clay had been forced '*en masse*' *up hill* over inclined calp beds. We brought home some specimens of scratched faces of rock, and subsequently I caused some pretty large scratched boulders to be carted away, and deposited them in the Museum of the Geological Society previously to our next Council meeting, which was held on the 5th June, 1844, and at which Professor Phillips was present, to whom I communicated my views, that the scratches which we had observed together had been caused by the movement *en masse* of the clay and gravel beds over the rock beneath, and that the scratches upon the latter, as well as those upon the large boulders reposing on the rock and imbedded in the clay, had been produced by their being carried over the rock along with the moving masses of clay and gravel, &c.

"On the 12th November, 1845, I read the first part of a substantive paper on this subject to the Geological Society of Dublin, in which, having enlarged my observations at Killester by many others in various other and distant localities, I ventured to enunciate the doctrine, that the lateral movement of masses of mud, sand, and gravel, while in a wet and plastic state, either under the sea, or upon land very recently elevated above it, had been the great agent, not only in the almost universal scratchings observable upon the surface of the rocks of every part of the earth, but had been also the means of transport of the far larger proportion of the boulders and greater drift masses that cover the earth. I showed the close similarity that exists between the motions internal and external of a moving mass of mud or sand, and gravel, or of vast landslips, and of those of glaciers; and at the Cambridge meeting of the British Association, on occasion of the discussion in the Geological Section of a paper on the Scratched Rocks of the Isle of Man, I referred them to the movements of such 'mud glaciers,' a view which Professor Sedgwick, the President of the Section, coincided in.

"I have, at subsequent periods, frequently alluded in discussion to this view, and greatly regret that other avocations have as yet prevented my developing the important consequences which I believe can be shown to follow from this peculiar move-

ment of loose material, considered as a general cosmical force, perpetually acting round every coast, at the present day, and having acted on a perhaps still grander scale at former periods of great elevations and depressions, above and below the ocean.

"I believe that the lateral movements due to gravitation of masses of loose material, whether mud, sand, gravel, or all of these, mixed with boulders, will, when combined with the acknowledged agency of elevation and depression, and with the already ascertained laws and known effects (as we observe them now) of tidal action, and those of the motions of fresh-water precipitations over the land, be found a sufficient mechanism to account for the transport to any distance of drift and boulders, and be ultimately admitted, as *the vera causa*, the appointed agents for such removal; and that glacial action, whether of floating icebergs, of drift ice in rivers or estuaries, or of glaciers, although it may be, or have been, an occasional and accidental agent in such transport, and in producing scratches which are evidence of it, have yet not been the main or even important agent in that which constitutes one of the vastest phenomena that our earth's surface presents, namely, the transport, by natural agency, of loose material over it.

"Should these views hereafter be found correct, as I firmly believe they will prove to be, many investigators will be found, as in every generalization, to have had some notion, more or less near to the truth, though not the truth itself, and as in every such case many claims to priority of discovery arise which are hard to investigate, and troublesome to consider, but which the parties interested are naturally anxious should be determined, I am desirous now to claim, in a formal manner, whatever share may justly belong to me as the first (so far as I know) to form and publish the ideas which I have in the preceding lines very imperfectly stated.

"I am anxious to do so now, and in the present form of a letter to yourself, because you were my companion and joint investigator at their very origin, have known the periods and terms in which I have affirmed my views, and have, I am glad to say, given them, to a great extent, your own sanction. Will you, therefore, as I shall not be able to present myself at the next meeting of the Geological Society of Dublin, communicate this letter, or such portion of it as you deem best, to the meeting; and oblige,

"Yours very sincerely,

"Robert Mallet."

Note by Mr. Mallet—March 3, 1852.

The passage in Colonel Portlock's Notice of Scratches upon the Rocks of Bantry Bay,* which has induced the publication of the preceding documents, is as follows:— "It appeared to me that these scratches passed under the clay" (i. e. of the bluff headlands of boulder clay resting on scratched schists), "and my impression is, that the whole mass must have moved onwards, and that the pebbles that produced the scratches were imbedded in the clay." This is not a mere statement of a fact: it is also that of a theory to account for the facts.

My letter, as above, to Professor Oldham, 7th December, 1850, did not allude more specially to Colonel Portlock than to other authors. He has, however, thought proper

* Jour. Geol. Soc. vol. v. page 111.

to apply it individually; and in his Annual Address (of February, 1851) endeavours to defend himself from the self-imposed charge of plagiarism by attempting to show—

1. That my views as to movement of detrital masses had never been distinctly enunciated, or even clearly thought out by me.

2. That, according to his conception of my views, they were not new, and had been anticipated by former writers, differing, in fact, in nothing from all common views as to detrital movements.

3. That I had in some way altered, or changed, or extended, the expression of my views since their first promulgation, which, it is inferred, were never committed to published documents.

It has been unfortunate for one whose views have thus been subjected to *ex cathedra* criticism that this Annual Address never made its appearance in print, or in the hands of the members of the Society, until many months after the date of its delivery. It then appeared, with the addition of a note at page 109, which I have reason to believe formed no part of it when delivered to the Society.

The whole question of personal importance turns upon, whether—firstly, this doctrine of movement *en masse* of detritus had been ever clearly enunciated by me anterior to 13th November, 1850, when Colonel Portlock's paper was read; secondly, was the doctrine then original with me, or had it previously been enunciated clearly and distinctly by any other person.

The following passages, extracted from my own Presidential Addresses to the Society, will, I think, fully sustain my claim in both respects:—

"While I fully agree with Captain James in his view, that these marine deposits were precipitated in a tranquil sea, the tranquillity of which was due to the high lands then above the sea-level to the north and west, I can by no means subscribe to the prevalent doctrine of some one or more cataclysmal deluges having swept over the whole of the then submerged surface of Ireland, and convulsively carried along the so-called Northern Drift. On the contrary, I am impressed with the conviction, that the deposition of these tertiaries was due to the long-continued and comparatively quiet action of the tides and marine currents of the ancient ocean, acting upon the detritus of still more ancient lands, combined with the then active motions of elevation by which our island has been raised to its position above the sea-level. I would further venture to express my belief, that future and not distant researches will show that the ordinary motions of the sea in connexion with forces producing elevations of the land, both acting upon the loose materials of which the sea bottom principally consists, and producing therein great and varied movements laterally by sorting and direct transport, *and also by the slipping or movement "en masse" of the beds of loose materials, as mud, gravel, &c., on the inclined beds of rock supporting them, constitute a sufficient machinery to account for all the cases of transport hitherto observed.*"*

"There are few, if any, phenomena producible by the action of glaciers in motion that are not also producible by *aqueous forces acting on mixed masses of detritus of every sort, from mud to boulders, when combined with the slippage of the masses themselves upon their sustaining beds—even to the furrowing, rounding, and scratching of the rocks beneath.*"†

* President's Address, 10th Feb. 1847, p. 9. † Ibid. page 11.

Again, in my Address for 1848 :—

"The next paper was one by myself, in which I have endeavoured to show, that transport to vast distances of boulders or erratic blocks, of almost any conceivable magnitude, may be accounted for by the slow or occasionally rapid movement of semi-fluid masses of mud, gravel, sand, &c., mixed with those larger materials, when forming the bed of the sea, and either of sufficient depth and mass alone, or resting upon a base of rock, or other materials of very moderate slope, combined with the sorting and transporting power of the tidal currents for the finer materials of the whole mass. That, in fact, the vast accumulations of mud and sand, &c., involving all sorts of heterogeneous materials which constitute the great mass of the sea bottom, must, around the shores at any given time, be in constant motion outwards, forming what I have elsewhere called *mud glaciers*—a somewhat anomalous but expressive term. That these masses, reduced in water to nearly one-third of their weight, will move gradually on slopes of three or four degrees, or even less, and that when the length of plane is as enormous as it in many instances appears to be in the ocean bed, when fresh materials are constantly added to the finer mass by tidal estuary deposits, and fresh blocks supplied by the fall of rocky masses from shore cliffs, and when the outer edge or talus of such banks, going into deeper water, is continually sorted and removed by tidal or oceanic currents crossing the line of slippage, or motion of the mass, transport of the contained blocks may be accounted for to vast distances, and taking in the element of successive elevation of land, and hence of new shores, being pushed further and further out, that this machinery alone is sufficient to account for transport of blocks to an indefinite distance.

"The actions of breaking waves in shallows and on shores have been much confounded with those of the unbreaking waves of translation. The former are incessantly at work. Let their powers and their effects be studied with care, and above all in the clearness of exact science;—let the results of their actions be connected with those of tidal and of ocean currents, as now known to exist, and connected also with such gradual or *per saltem* elevations or depressions of the land, above or below the sea, viewed as a fixed horizon, as we have observed;—and lastly, let all these be connected with the movements of loose materials going on in the existing sea bottoms, by the fluency or semi-fluid motions of these vast masses of matter, reposing on inclined beds, which beds are themselves subject to changes of inclination, as well as to elevation and depression;—and from the whole I am bold enough to venture a prediction, that no phenomena of transported materials, however vast, have yet been observed, that such a machinery will not be found sufficient to account for. In these, I believe, will be found the *vera causa* of northern and other great drifts—to the passage of these mud glaciers (to use this term again) over surfaces of rock below the sea, may be traced the furrows and groovings as to which so much has been written, but which are now at length admitted to have been produced principally under water, and in all possible directions, neither universally accordant with tidal nor with glacier directions of motion, but with the slope of the rock beneath ; and to these shore or breaking waves may be attributed those gigantic cauldrons (the Riesenötpfe) of the Scandinavian rocks, which neither glaciers nor icebergs can throw any light upon.

"But while I state my conviction, that the connecting forces above stated will

yet be found to be the true and general cause of drift transport, I readily admit that icebergs cast afloat have been, as they are now, an occasional means of transporting a freight of foreign rocky and other matter to vast distances; and may have been the carriers of many of our boulders found isolated to great distances from their originating rocks; but their powers seem quite inadequate to the gigantic task that has been affirmed of them as the universal drift carriers. The great operations of nature are always performed by forces steadily in action, yet others, only called occasionally, or, as it were, accidentally, into play, do sometimes subordinately act in concert with, and, as it were, simulate the functions of these; and the remarks of Mr. Milne on this subject, as referring to the drifted materials of Scotland, seems to be conclusive, that iceberg action may here, at least in part, have been the carrying agent."*

Upon these quotations I rest the issue of the claim that I here again make of having been the first to promulgate the doctrines they enunciate. They prove that my views were from the outset clearly stated, and therefore clearly conceived, and that from their first publication in 1844 to the present hour I have neither altered, changed, nor added aught to their statement.

It is with pain, therefore, that I feel compelled to notice as unwarranted the charge (so grave if it were true) to be deduced from the following sentence of Colonel Portlock's Address:—"I have endeavoured to represent it as I conceived it to have been delivered *originally* by its author, *but he now states* that he intended to extend the principle of slips to detrital matter under water."† The Italics are mine.

How far these views of mine are original, and how far, if at all, they have been anticipated by those of other and former writers, geologists will decide for themselves. Whether Colonel Portlock has understood or misunderstood my views, it is not for me to discuss; but I must continue to believe that he has not yet grasped the leading idea of them, for I have too high a respect for him to suppose that otherwise be would have laboured through pages 63, 64, 65, 66, *et seq.*, in endeavouring to show identity between my views and those of M'Culloch, Dausse, D'Halloy, and others, with which they have not the remotest similarity or connexion, as any reader of the whole originals, *with their contexts*, cannot fail to find.

As to Colonel Portlock's present opinion of the value, or want of value, of these views of mine, I can afford to wait. Meanwhile, geologists will, no doubt, receive with caution any opinion the author of which professes to have adopted it from "any vague perception," and I feel assured that in time to come Colonel Portlock will entertain clearer notions, and, in common with many other geologists, distinguished as he so justly is, will recognise with me the importance to geology of movements *en masse* of detrital deposits.

I have felt compelled, though with much reluctance, to add the preceding note to my communication, in consequence of the matter introduced subsequently to the delivery of the President's Address; but here, so far as I am concerned, the controversy shall end. Life is too short, the value of an unruffled spirit too great, to waste it in discussion one moment after it ceases to be on all sides an earnest seeking after truth alone.

* President's Address, 9th Feb. 1848, pp. 18, 19. † Ibid. page 109.

November 12, 1851.—"Notes on the Geology of Rathlin Island;" by the Rev. Samuel Haughton, M. A., Professor of Geology in the University of Dublin.

Mr. Haughton described the relations between the chalk and overlying basalt observed by him during a recent visit to the island of Rathlin. The account of the geology of the island was accompanied by diagrams and maps illustrating the structure of the basalt of the island. The woodcuts accompanying the present notice of Mr. Haughton's paper are reduced from larger views of sketches taken on the spot.

On inspecting the accompanying map of the island (fig. 1), it is apparent that the island is composed of basalt resting upon chalk, which only appears at intervals round the sea-coast, lying underneath the mass of tabular and eruptive trap which has been poured over the surface of the island, as in the adjoining districts of the main land.

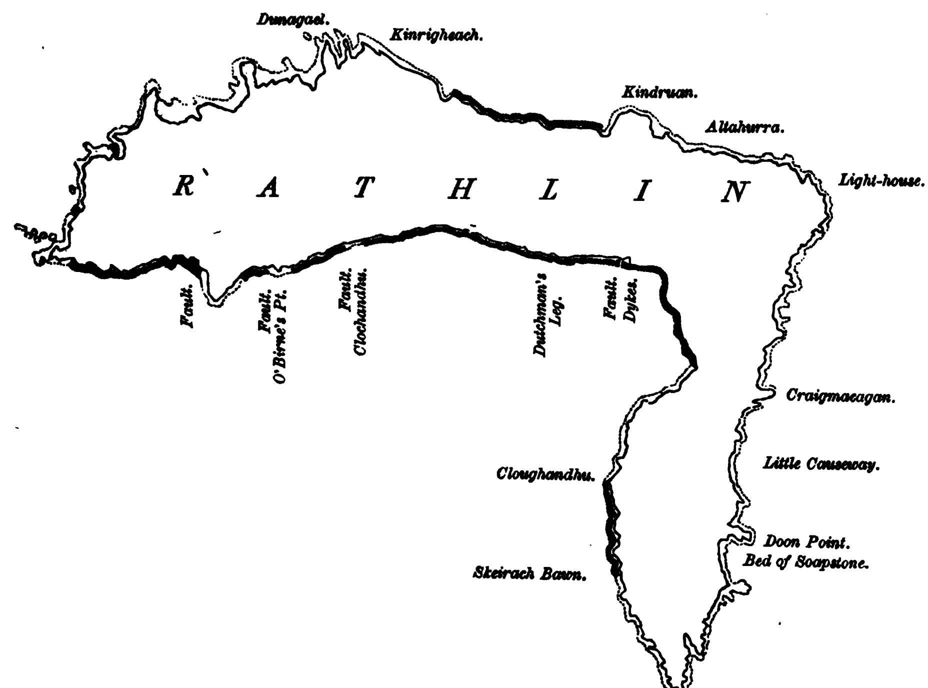
Commencing at Kindruan Head on the north, which is composed of massive and tabular basalt, rising to the height of 375 feet, and resting on the west upon a ledge of chalk rocks, which do not rise above the sea-level, and proceeding eastward along Altahurra Bay, the trap gradually diminishes in height, until, at the lighthouse at the north-east point, it only rises to a height of 178 feet above the sea-level. The trap forming the cliff on which the lighthouse is built is tabular, and the sheets dip south-west.

The whole of the east coast of the island is composed of basalt, not rising, in general, above 80 feet, sometimes tabular, having its beds separated by two or three thin layers of ochre; and sometimes, as at Craignacagan and Doon Point, the basalt exhibits a columnar structure of the most singular and apparently irregular arrangement. At the former place the columns are arranged vertically, and these are capped by another series of smaller columns inclined at various angles to the former.

About half-way between Craignacagan and Doon Point the remarkable fan-shaped arrangement of basaltic columns represented in fig. 2 occurs. It is called the Little Causeway, and nothing can exceed the irregularity of the directions of the pillars in the portion represented in the sketch; the general arrangement is vertical, but every variety of inclination occurs, from horizontal to vertical.

Figure 3 represents a view of Doon Point from the south, and of the curiously curved columns of basalt which form the northern

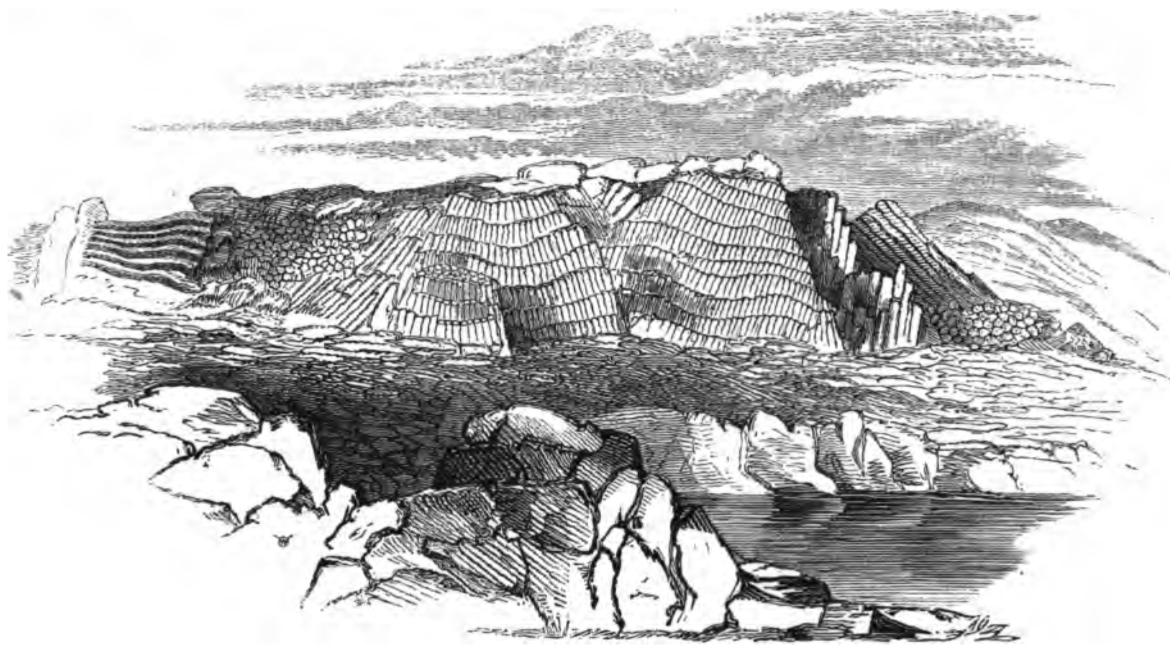
Fig. 1.



GEOLOGICAL MAP OF RATHLIN ISLAND.

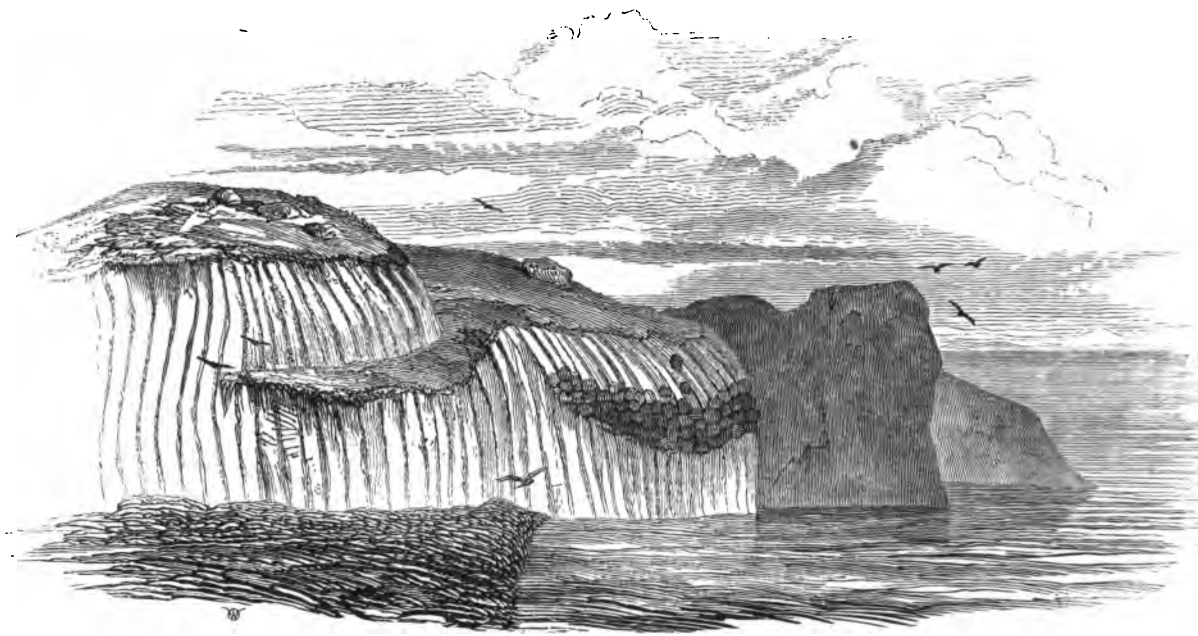
The unshaded portion of the Island is Basalt. The shaded portion, round the sea-coast, is Chalk.

Fig. 2.



THE LITTLE CAUSEWAY, EAST COAST OF RATHLIN.

Fig. 3.



VIEW OF DOON POINT, FROM THE SOUTH.

boundary of the Bay to the south of the Point. The curvature of some of the pillars is continuous through 90°, and they pass from the vertical to the horizontal position, exhibiting, however, a tendency to break at the point of greatest flexure, which has caused most of them to be broken off by the action of the sea.

The Bay south of Doon Point contains beds of ochre and soapstone, the latter contained in amygdaloidal cavities of decomposing trap; the bedding of both is conformable to that of the tabular trap.

The basalt continues without interruption round the southern point of the island, to the point marked Skirach Bawn, or the White Rock, where it rises to the height of 218 feet, and rests upon ledges of chalk, which crop out from under it at the sea-level, and continue as far as the point called Cloughandhu, or the Black Rock, when the trap again covers up the chalk, which does not again appear until we reach the south side of Church Bay, a few yards to the north of the mill. The chalk constitutes the shores of Church Bay, and continues, with the interruptions marked on the map, to the western point of the island, called Bull Point. The chalk reaches its highest elevation along the line of cliffs running from Church Bay to Bull Point, and sometimes rises to one-third of the height of the cliff, being, however, always surmounted by tabular basalt.

There is a remarkable fault, accompanied by basaltic dykes, running N. S. up the valley, immediately to the west of the church. These dykes are described by Messrs. Conybeare and Buckland.* The measurement of the three dykes which are visible on the shore, reckoned from east to west, as given by Messrs. Conybeare and Buckland, is as follows:—

First, or eastern dyke, 20 feet; second, or middle dyke, 1 foot; third, or western dyke, 35 feet; the interval between Nos. 1 and 3 being 20 feet.

The measurement of these dykes obtained by Mr. Haughton is somewhat different, being probably taken at a different point:

Eastern dyke, 29 feet (approximate measurement, in consequence of the dyke being partly covered by the shingle).

Middle dyke, 3–4 feet.

Western dyke, 94 feet; becomes thinner as it runs south towards the sea.

Breadth of chalk between eastern and western dykes, 121 feet.

* Trans. of the Geol. Soc. of London, vol. iii. p. 210.

These three dykes bear N. 5° W., which line, if prolonged to the south, would intersect the Ballycastle collieries, for which reason Mr. Haughton is inclined to connect the dykes in Church Bay with the system of dykes belonging to Fair Head, and not with the dykes of Kenbawn Head, as proposed by Messrs. Conybeare and Buckland.

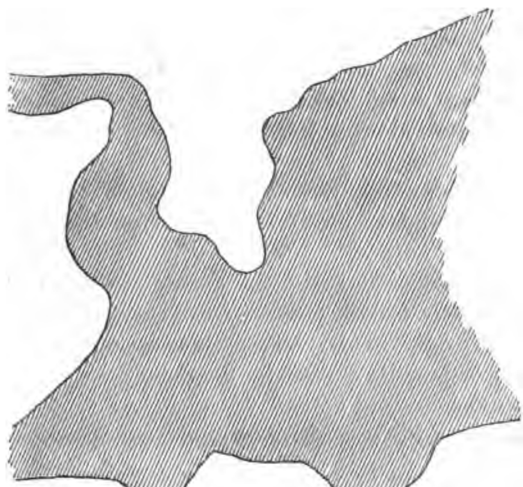
In order to verify this connection, Mr. Haughton measured the bearing of the four principal dykes of the Ballycastle colliery, and found them, proceeding from east to west, as follows:—

Carrickmore dyke	bears	N. 10° E.
Pollard dyke	,,	N. 15° W.
West Mine dyke	,,	N. 10° W.
North Star dyke	,,	N. 5° W.

The beds of chalk in Church Bay are nearly horizontal, but dip slightly N. 10° W.

The downthrow of the fault accompanying the dykes at the church is to the eastern side. The chalk is, as usual, altered into a blue crystalline limestone, by contact with the dykes.

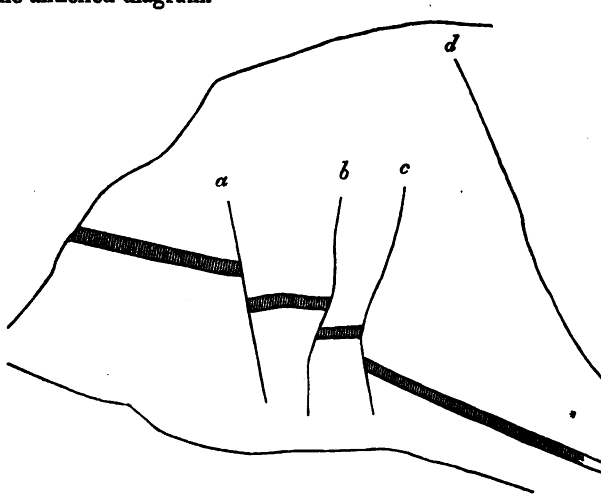
A few yards to the east of the dykes there occurs a section of the vein of basalt penetrating the chalk, which is represented in plan in the annexed woodcut, in which the shaded portion represents basalt, and the unshaded portion the chalk through which it penetrates.



Between Church Bay and Bull Point, the chalk is interrupted in the cliffs three times by the occurrence of faults, accompanied by

downthrows to the east. The three headlands composed of basalt are called Halfway Point, O'Birne's Point, and Stroandergan; the fault occurs at the western side of these headlands; but there does not appear to be any trace of eruptive trap at these points.

The chalk appears in three places on the sea-level, cropping out from under the basalt, on the north side of the island; these points are marked on the map. From the lower level of the chalk on the northern side of the island, a general dip towards the north of the bed of chalk may be presumed; but the general dip of the masses of tabular trap covering the chalk at the north side of the island is to the south-west. This is particularly observable at Dunagael, where a bed of lignite occurs, from six to ten inches thick, and lying between two thick beds of columnar basalt. To the west of Dunagael lies the headland ralled Kebble Head, on the west side of which the bed of ochre, which separates the masses of tabular trap in the upper part of the cliff, is broken by faults in the manner exhibited in the annexed diagram.



The shaded stratum represents the bed of ochre, broken in three places by the faults *a*, *b*, *c*. This breaking up of the beds of tabular trap after their deposition is universal through the island; the strata are broken by innumerable faults and fissures, which render it difficult to observe the relations which exist between the trap and chalk.

The bed which appears in Altahuile Bay, west of Kindruan, is the most extensive development of the chalk on the north side of Rathlin.

December 10, 1851.—"Upon the composition of a new variety of metallic ore, from the Vale of Ovoca, County of Wicklow;" by James Apjohn, M.D., Professor of Chemistry and Mineralogy, Trinity College, Dublin.

In the course of the past summer I received from George M'Dowell, Esq., one of the Junior Fellows of the University, a mineral substance, which was obviously a metallic ore, with a request that I would inform him of its exact composition. This mineral, which he described as constituting a central mass or nucleus within a newly discovered lode, or bed of sulphur ore, in the Ballymurtagh district, was massive, of a leaden colour, with tinge of brown, and exhibited numerous intermixed particles of yellow iron pyrites. Its specific gravity was found to be 4.4955, and, heated on charcoal by the outer flame of the blow-pipe, sulphur was burnt off, a yellowish-white oxide was deposited on the charcoal, and the ordinary flame being finally applied, a small globule of lead was with difficulty procured.

When acted upon by strong muriatic acid in excess, and at a boiling temperature, sulphuretted hydrogen was disengaged, a portion of the mineral remained unaltered, which proved to be the bisulphuret of iron, or common pyrites, while the *solution*, when tested by the appropriate re-agents, was found to include the chlorides of lead and zinc, and the protochloride of iron.

In effecting the quantitative analysis of this mineral, the same solvent (muriatic acid) was employed, and the bisulphuret of iron which it left undissolved was well washed with boiling water, and, after being dried at 212°, was weighed. The dissolved chlorides were now treated with a little nitric acid, and the solution having been evaporated nearly to dryness, the chloride of zinc and sesquichloride of iron were dissolved out by rectified spirits. The chloride of lead, thus insulated, having been dried and weighed, water of ammonia was added in excess to an aqueous solution of the other chlorides, which precipitated the peroxide of iron, and redissolved the oxide of zinc. The peroxide of iron was now collected on a filter,

and, when well washed, was ignited and weighed; and the ammoniacal solution of chloride of zinc having been evaporated to dryness, the residue was acidulated with sulphuric acid, and after another evaporation, and exposing the residual sulphate of zinc to a low red heat, its weight was accurately taken.

The chloride of lead, sesqui-oxide of iron, and sulphate of zinc being now, by calculation, reduced to sulphurets, the following results were obtained:—

Bisulphuret of Iron, $Fe\,S_2$, ... : . . .	24.97
Sulphuret of Iron, $Fe\,S$, ...	7.33
Sulphuret of Lead, $Pb\,S$, ...	19.18
Sulphuret of Zinc, $Zn\,S$, ...	46.62
	100.00

Neglecting the iron pyrites, which is obviously a mechanical intermixture, the residual constituents are very accurately expressed by the following formulæ:—

$$Fe\,S + Pb\,S + 6Zn\,S.$$

Upon a second analysis the same formula was found to be very nearly applicable, so that, notwithstanding the singularity of the constitution of this mineral, all its proximate constituents being basic sulphurets, I am disposed to consider it as a distinct and definite compound.

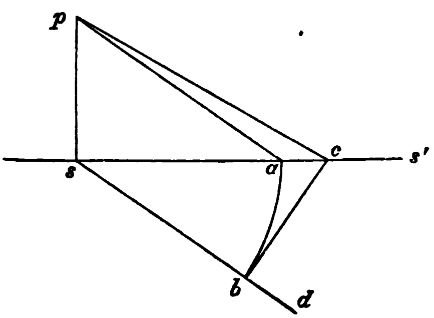
December 10, 1851.

Frederick J. Sidney, Esq., LL.D., exhibited a map and section made by him, in conjunction with Mr. H. Medlicott, in the neighbourhood of the town of Wexford. The map, comprising sheet 42 of the Ordnance Survey of the county, and the section* being taken from a point N.W. of Carrickadee Rocks to Finoge Bridge, being in a direction nearly N.W. and S.E., and about six miles in length. The limestone in the immediate vicinity of the town is magnesian, alternating with beds of shale. There are several quarries in the neighbourhood, in some of which the limestone is highly crystalline and full of small cavities. In some instances, native sulphur, in a state of great purity, was found in the cavities. The average dip of the limestone is about 25°, towards the S.E. Conformable to the lime-

* Vide section 1, pl. I.

stone is the old red sandstone and conglomerate, which appears on the flanks of the hills, which run in a S.W. direction from the town. The hills are composed of quartz rock, alternating with clay slate, and dipping in the opposite direction to the limestone and old red sandstone, and at a higher angle. A greenstone dyke occurs close to the line of section; the greenstone is wholly decomposed into yellow ochre.

NOTE. The dip, as laid down in the section, is not the actual dip of the strata, the section not being exactly at right angles to the strike, but represents the actual intersection of the plane of the section with that of the beds, and is plotted as follows:—ss' being the direction of the section, and p the point of observation. Draw sd, making the angle $s'sd$ = the angle contained between the direction of the dip and that of the section. Make the angle spa = the complement of the observed dip. Make $sb = sa$, and erect the perpendicular bc; pc is the line required; the correction for the deviation of the line of section from that of the dip being thus the angle apc.



The above construction appears simpler in practice than the method usually adopted, which is by calculation, either with the aid of the sliding rule, or of trigonometrical tables.

January 14, 1852.—"Notes on the Serpentines of Cornwall and Connemara;" by the Rev. SAMUEL HAUGHTON, M. A., Professor of Geology in the University of Dublin.

MR. HAUGHTON communicated the following notes on the Lizard district of Cornwall and the serpentine quarries of Connemara.

At junction of serpentine, with hornblende slate, between Cury and Mullion, dip of slate is 28° W. 40° S., with joint planes, N. 20° E.

At junction at Landewednack, the hornblende rock is separated from serpentine by a stream; dip of hornblende slate, W. 10° S. A

vein of ochreous clay runs through the serpentine at its junction with the hornblende rock.

At the Lizard Head, junction of mica slate with hornblende slate, near lighthouse: dip E. 40° N.

Junction of hornblende slate and serpentine, north-west of Lizard Head, marked by a vein of purple clay; dip of hornblende slate, E. 40° S.

The hornblende slate and mica slate, north of Lizard Point, appear to alternate with each other.

At Mullion Churchtown, junction of hornblende slate and serpentine; dip of slate is W. 10° N.

Veins of steatite and green serpentine occur in the serpentine porphyry, at Kynance Cove. Native copper occurs, with steatite and some carbonate of lime, at Mullion.

I. *Analysis of Steatite, or English Soapstone, from Gue Grease, near Kynance.*

	Per Cent.	Atoms.		Integer Atoms.	
$Si\,O_3$ =	42.10 =	0.939 ...	6.29	6	13
$Al_2\,O_3$ =	7.67 =	0.149 ...	1.008	1	2
$Mg\,O$ =	30.57 =	1.477 ...	10.00	10	21
$H\,O$ =	18.46 =	2.051 ...	13.81	14	29
	98.80				

From the first set of integer atoms, the rational formula would probably be

$$5\{2\,Mg\,O,\,Si\,O_3\} + \{Al_2\,O_3,\,Si\,O_3\} + 14\,H\,O. \qquad (1)$$

The second set of integers represents still more closely the results of the analysis, and is identical with the series of numbers deduced by Rammelsberg from Svanberg's analysis of the English soapstone, with the exception of the number of atoms of water.

From Svanberg's analysis, Rammelsberg deduces this rational formula:

$$\{3\,(3\,Mg\,O,\,Si\,O_3) + 2\,(Al_2\,O_3,\,Si\,O_3) + 3\,H\,O\} + 4\,\{3\,Mg\,O,\,2\,Si\,O_3 + 3\,H\,O\} \quad (2)$$

The first formula represents the analysis nearly as well, and has the advantage of being less complicated.

The analysis of Klaproth cannot be reconciled with Svanberg's or Mr. Haughton's.

II. *Analysis of Soapstone from Kynance Cove.*

	Per Cent.	Atoms.	Integer Atoms.	
$Si\,O_3$	= 42.47	0.937	6.78	7
$Al_2\,O_3$	= 6.65	0.129	0.93	1
$Mg\,O$	= 28.83	1.398	10.00	10
$H\,O$	= 19.87	2.152	15.44	15
	97.82			

Hence its formula is—

$$5\{2\,Mg\,O,\ Si\,O_3\} + \{Al_2\,O_3,\ 2\,Si\,O_3\} + 15\,H\,O. \qquad (3)$$

Combining the two soapstones, we find the probable composition:

	Atoms.
$Si\,O_3$	= 18
$Al_2\,O_3$	= 2
$R\,O$	= 20
$H\,O$	= 28

Hence the mean formula is—

$$10\{2\,Mg\,O,\ Si\,O_3\} + \{2\,Al_2\,O_3,\ 3\,Si\,O_3\} + 28\,H\,O \qquad (4)$$

Connemara Serpentines.

The strike of thinly-bedded quartz rocks in the neighbourhood of Mr. D'Arcy's quarry, between Clifden and Moyard, is E.W. Strike of beds of serpentine, or verd antique, which is mixed with masses of purer limestone, is E. 10° S., W. 10° N.

The bedding is rather doubtful, but the strike of the beds is easily ascertained.

III. *Analysis of Serpentine from Ballinahinch Quarry.*

	Per Cent.	Atoms.		Integer Atoms.	
$Si\,O_3$	= 40.12	0.885	1.000	10	5
$Mg\,O$	= 40.04	1.984	2.191	22	11
$Fe\,O$	= 3.47	0.096			
$H\,O$	= 13.36	1.484	1.676	16	8
$C\,O_2$	= 2.00	0.091			
$Ca\,O$	trace.				
$Al_2\,O_3$	trace.				
	98.99				

The result of this analysis, which was made by the Rev. Joseph A. Galbraith, proves (if the atomic weight of magnesia be 20.1) that the Ballinahinch serpentine corresponds with the formula deduced

by Rammelsberg, as the *mean* of thirteen good results from different localities. Its rational formula is, therefore, according to Rammelsberg,

$$\{2\,(3\,Mg\,O,\ 2\,Si\,O_3) + 3\,H\,O\} + 3\,\{Mg\,O,\ H\,O\} \qquad (5)$$

Or, with the usual weight of Mg O

$$5\{2\,Mg\,O,\ Si\,O_3 + H\,O\} + \{Mg\,O,\ 3\,H\,O\} \qquad (6)$$

IV. *Analysis of red earthy base of Serpentine Porphyry, from Kynance Cove.*

	Per Cent.
$Si\,O_3$ =	38.29
$Fe_2\,O_3$ =	15.00
$Mg\,O$ =	34.24
$H\,O$ =	12.09
	99.62

Converting $Fe_2\,O_3$ into Fe O, we find

	Per Cent.	Atoms.	Integers.
$Si\,O_3$ =	38.29	0.845	10.00
$Fe\,O$ =	13.50	0.375	24.00
$Mg\,O$ =	34.24	1.654	
$H\,O$ =	12.09	1.343	15.89

Hence we obtain finally, for the integer atoms:

$$Si\,O_3 = 5$$
$$R\,O = 12$$
$$H\,O = 8$$

The Ballinahinch serpentine gave,

$$Si\,O_3 = 5$$
$$R\,O = 11$$
$$H\,O = 8$$

If only *half* the iron be present in the porphyry as protoxide and the rest as peroxide, mechanically combined, the Cornish porphyry will be identical with the Galway serpentine.

It is worthy of remark that the blow-pipe is sufficient to distinguish the red paste of the porphyry from any variety of feldspar, with which it has been often confounded.

AT THE

ANNUAL GENERAL MEETING

HELD ON

WEDNESDAY, FEBRUARY 11th, 1852,

REV. JOSEPH A. GALBRAITH, F.T.C.D., IN THE CHAIR,

The following Report from the Council was read and adopted:

THE Council have to offer to the Society the following Report for the past year.

Seven new members have been added to the Society, viz.:—Joseph Beete Jukes, M. A.; John Irvine Whitty, Esq.; George M'Dowell, F. T. C. D.; Edward Wright, LL. D.; Henry Medlicott, Esq.; Alexander Jack, Esq. (formerly Associate); and Rev. John H. Jellett, Professor of Natural Philosophy, University of Dublin.

The following Associate Members have joined the Society:—George H. Kinahan, Esq.; Arthur A. Jacob, Esq.; John Kennedy, Esq.; John Cogan, Esq.; William Thornhill, Esq.; John K. Reid, Esq.; and Joseph O'Kelly, Esq.

Withdrawn or deceased:—William Hogan, Esq.; A. G. Melville, M. D.; Sir James Murray; Arthur Todd, Esq; Arthur Jacob, M. D.; Franc Sadlier, D. D., late Provost of Trinity College; and Richard Purdy, Esq.

The Society, in common with many other public institutions of Dublin, have to deplore the removal by death of the late Provost of Trinity College, who was one of the oldest members of this Society, and felt much interest in its welfare.

The Society at present numbers: 4 Honorary Members, 35 Life Members, 83 Annual Members, and 10 Associates; total amounting to 132 members.

After due consideration, it was not deemed advisable to renew the offer of prizes for papers contributed to the Society, and your

Council desire to impress upon the members of the Society generally the necessity of relying altogether upon their own exertions, and trust they may next year have to report a large accession to the working members of the Society.

During the past year, your Council have published the First Part of Vol. V. of the Journal of the Society, and trust that the Society will not meet with any disappointment as to the speedy publication of their subsequent Proceedings.

During the past year, the Council have had to contend with serious financial difficulties, arising partly from the negligence of some members in paying their subscriptions in time to enable the Council to carry out fully, by means of cash payments, their plans of financial reform. They trust, however, that this is the last time they shall be obliged to report difficulties of this description.

The Treasurer's account, as annexed, shows a balance due to the Treasurer of £26 *5s.* 10¼*d.*

The following list contains an account of the Donations made to the Society during the past year.

DONATIONS

RECEIVED SINCE LAST ANNIVERSARY.

1851.

March 4.—Quarterly Journal of the Geological Society of London, No. 25. Presented by the Society.

May 7.—Address to the Geological Society of London, 21st February, 1851, by Sir Charles Lyell, F. R. S., &c. Presented by the Author.

May 21.—Tabular View of the Order of Deposition, &c., of the principal European Groups of Stratified Rocks, by Capt. R. Smith. Presented by the Publisher, Mr. Samuel B. Oldham.

May 21.—Geological Maps of the Counties of Dublin and Wexford. Presented by the Chief Commissioner of Woods and Forests, through Sir Henry T. De la Beche.

June 4.—Quarterly Journal of the Geological Society of London, No. 26. Presented by the Society.

June 9.—The Mining Journal, No. 823. Presented by the Editor.

June 9.—Twenty-third Annual Report of the Bristol Institution. Presented by the Institution.

June 27.—Transactions of the Institution of Civil Engineers, Vols. I. to III.; Minutes of Proceedings, Vols. I. to VI., with portions of Vols. VII. to IX.; List of the Members, and a new Catalogue of the Library. Presented by the Institution.

Aug. 21.—Quarterly Journal of the Geological Society of London, No. 27. Presented by the Society.

Sept. 19.—Transactions of the Kilkenny Archæological Society, for the year 1850. Presented by the Society.

Oct. 20.—Researches in Terrestrial Physics, by Henry Hennessy, M. R. I. A. Presented by the Author.

1851.

Oct. 30.—Proceedings of the Royal Irish Academy, Vol. IV., Part 3, and Vol. V., Part 1. Presented by the Academy.

Nov. 12.—The Mining Journal, No. 846. Presented by the Editor.

Dec. 3.—Quarterly Journal of the Geological Society of London, No. 28. Presented by the Society.

Dec. 8.—Lithograph of a Cork tree (*Quercus suber*), now growing at Summerstown, near Cork. Published for the Cork Cuvierian Society, and presented by them.

Dec. 24.—Museum of Practical Geology.—Government School of Mines and of Science applied to the Arts. Inaugural Discourse at the opening of the School, 6th November, 1851, by Sir Henry T. De la Beche. The Relations of Natural History to Geology and the Arts, by Edward Forbes. On the importance of cultivating Habits of Observation, by Robert Hunt; and, On the National Importance of studying Abstract Science, with a view to the healthy Progress of Industry, by Lyon Playfair. The whole presented by Sir Henry T. De la Beche.

1852.

Jan. 1.—Report of the British Association for the Advancement of Science, for 1850. Presented by the Association.

Jan. 7.—Journal of the Royal Geographical Society of London, Vol. XXI. (1851). Presented by the Society.

Jan. 14.—The Athenæum, June to December, 1851. Presented by the Editor.

Jan. 14.—The Literary Gazette, 1851. Presented by the Editor.

Jan. 14.—Specimens of Lithodendra and other Fossils, from Lough Gill, County Sligo. Presented by John Wynne, Esq., Hazlewood, County Sligo.

ADMISSION FEES.

	£	s.	d.
Henry Head, M. D.,	1	0	0
J. I. Whitty, Esq.,	1	0	0
J. B. Jukes, Esq.,	1	0	0
R. Hitchcock, Esq.,	1	0	0
E. Wright, Esq.,	1	0	0
Lord Talbot de Malahide,	1	0	0
	£6	0	0

SUBSCRIPTIONS.

	£	s.	d.
Rev. J. Galbraith,	1	0	0
John Patten, Esq.,	1	0	0
W. T. Mulvany, Esq.,	1	0	0
Thomas Maguire, Esq.,	1	0	0
Doctor Harrison,	1	0	0
M. D'Arcy, Esq.,	1	0	0
A. M. Giles, Esq.,	1	0	0
J. Petherick, Esq.,	1	0	0
Thomas Hutton, Esq.,	1	0	0
Colonel Portlock,	1	0	0
J. G. Medlicott, Esq. (1850),	0	5	0
J. G. Medlicott, Esq.,	1	0	0
F. W. Burton, Esq.,	1	0	0
J. G. Nicholson, Esq. (1850–1851),	2	0	0
Thaddeus O'Mahony, Esq.,	0	5	0
Doctor MacDonnell,	1	0	0
S. Downing, Esq. (1850–51),	2	0	0
T. M. Hutton, Esq., do.	2	0	0
H. W. Allen, Esq.,	1	0	0
Dr. H. Head,	1	0	0
Professor Allman,	1	0	0
Robert Callwell, Esq.,	1	0	0
Thos. Hamilton, Esq. (1850–1851),	2	0	0
A. Jack, Esq.,	0	5	0
J. I. Whitty, Esq.,	1	0	0
Carried forward,	£26	15	0

	£	s.	d.
Brought forward,	26	15	0
F. J. Sidney, Esq.,	1	0	0
William Edington, Esq.,	1	0	0
F. M. Jennings, Esq. (1850–1851),	2	0	0
Lord Talbot de Malahide,	1	0	0
Dr. Jacob,	1	0	0
B. D. Gibbons, Esq. (1849–1850–1851),	3	0	0
William Dawson, Esq.,	1	0	0
E. Dawson, Esq.,	1	0	0
J. Welland, Esq.,	1	0	0
Thomas Brien, Esq.,	1	0	0
Dr. R. Ball,	1	0	0
Richard Griffith, LL. D.	1	0	0
Rev. Dr. Wall,	1	0	0
C. P. Croker, M.D.,	1	0	0
P. Byrne, Esq. (1850-51),	2	0	0
A. M. Giles, Esq.,	1	0	0
John Radcliffe, Esq.,	1	0	0
R. Hitchcock, Esq.,	1	0	0
Rev. S. Haughton,	1	0	0
John Purser, Esq.,	1	0	0
Dr. Apjohn (1850-51)	2	0	0
E. Wright, Esq.,	1	0	0
Dr. Harvey,	1	0	0
Dr. Duncan,	1	0	0
	£55	15	0

ABSTRACT OF TREASURER'S ACCOUNTS FOR THE YEAR ENDING FEBRUARY, 1852.

Dr.

		£ s. d.
To Balance of last year's Account,		29 13 10½
— Admission Fees,	£6 0 0	
— Subscriptions,	55 15 0	
		61 15 0
— Received from Mr. Oldham for Journals sold,	2 2 6	
Do. do.,	0 5 6	
		2 8 0
— One year's Interest to 5th January, 1852, on £80 12*s.* 3*d.*, 3¼ per Cent. Stock,		2 12 4
— Balance due to Treasurer,		26 5 10½
		£122 15 1

Cr.

			£ s. d.
1851.			
April 2.	—By paid Mr. Oldham's Account for Printing, &c.,	£68 5 3	
	— Servant in charge of Room,	1 10 0	
	— Porter's Wages,	2 0 0	
	— For Advertising, and small expenses,	0 18 6	
	(Per Draft 8810)		72 13 9
Nov. 5.	—By paid Assistant Secretary's salary to 14th August, 1851,	£10 0 0	
	— Sundry expenses, per Assistant Secretary's book,	12 10 11	
	— Mr. Oldham's Account for Printing, &c.,	6 13 0	
	(Per Draft 8811)		29 3 11
1852.			
Feb. 4.	—By paid Assistant Secretary's salary to 14th inst.,	£10 0 0	
	— Sundry expenses, per book,	4 16 0	
	— Mr. Oldham's Account,	2 19 8	
	(Per Draft 8812)		17 15 8
	— By Collector's Poundage,		3 1 9
			£122 15 1

11th February, 1852.

WILLIAM EDINGTON, *Treasurer.*
JOSEPH A. GALBRAITH, *Chairman.*

The following Officers for the ensuing year were then declared duly elected, and the Society adjourned to receive the President's Annual Address:—

President:

ROBERT BALL, LL.D.

Vice-Presidents:

HUMPHREY LLOYD, D.D., S.F.T.C.D.

THE ARCHBISHOP OF DUBLIN.

LT.-COLONEL PORTLOCK, R.E.

ROBERT MALLET, C.E.

PROFESSOR ALLMAN, M.D.

Treasurers:

WILLIAM EDINGTON, ESQ.

SAMUEL DOWNING, C.E.

Secretaries:

REV. S. HAUGHTON, F.T.C.D.

FREDERICK J. SIDNEY, LL.D.

Council:

JAMES APJOHN, M.D.

RICHARD GRIFFITH, LL.D.

C. W. HAMILTON, ESQ.

JOHN MACDONNELL, M.D.

PROFESSOR HARRISON, M.D.

THOMAS HUTTON, ESQ.

ROBERT CALLWELL, ESQ.

PROFESSOR HARVEY, M.D.

REV. J. GALBRAITH, F.T.C.D.

JOHN KELLY, ESQ.

JOHN PETHERICK, ESQ.

JOHN KING, ESQ.

RIGHT HON. LORD TALBOT DE MALAHIDE.

JOSEPH BEETE JUKES, M.A.

HENRY HEAD, M.D.

March 10, 1852.—"Sketch of the Geology of the County of Waterford;" by J. Beete Jukes, M. A., Director of the Geological Survey of Ireland.

Mr. Jukes exhibited the map and sections of the Government Geological Survey of the county of Waterford, and read a paper to the Society, of which the following is an abstract:—

He premised that he appeared before the Society, not in his individual capacity, or as bringing forward the results of his own personal labours, but as the official representative of the department to which he belonged. The principal part of the work he described had been performed by the assistant geologists, Mr. W. S. Willson, Mr. G. V. Du Noyer, and Mr. Andrew Wyley. His own share of it had been almost entirely confined to the inspection of some of the principal points, and the harmonizing of the general results:—

The rocks that enter into the composition of the county of Waterford belong to the following formations:—

1. The Carboniferous.
2. The Devonian.
3. The Silurian.

He first briefly described the mineral and lithological character which these rocks assume in this district, and that of the igneous rocks associated with them; he then examined their actual and relative positions, and the lines of disturbance and dislocation by which they have been affected, and lastly mentioned some points of interest in the history of their formation. In the first description he commenced at the base of the lowest formation, and worked upwards.

The lowest beds we have in the County of Waterford are certain dark rotten slates, in some places fossiliferous, as at Newtown Head, where they are interstratified with beds of feldspathic ash, and contemporaneous feldspar trap. In the upper part of this band of slates there occur two little, calcareous beds, on the north and west side of the Bay of Tramore. The lowest of these is seen at a place called Quillia. It consists of beds of calcareous grit and sandstone, with a few bands of ash. It is full of organic remains, especially Trilobites, principally *Phacops Jamesii.* The uppermost limestone is seen at intervals for about seven miles, striking N.N.W. and S.S.E. through the town of Tramore. This limestone, in its lithological character, strongly reminded him of the Bala limestone of

North Wales, and its organic remains, though not yet fully examined, were believed to have a great similarity to those of that bed. Over this limestone comes a band of feldspathic trap and ashes, over which is another band of slate, and then a very large mass of trap of various kinds. This great expanse of trap forms an area twenty miles long by four or five in width, stretching from the north and west of Stradbally to the north and east of Waterford. Throughout this tract the rock appears very frequently at the surface in rough knobs and ridges of small hills, but these are so environed by thick masses of coarse drift, that no continuous section can be seen for any large distance. Where it strikes the southern coast, it forms cliffs of a rocky and precipitous character, often not easily accessible, very greatly indented by numerous coves and small bays, and little jutting headlands, and the general course of the coast line is so very oblique to the general strike of the rocks, that even here, where all the rocks are admirably exposed, it is difficult to arrive at any clear results as to their order of superposition and general relations. We get the same phenomena repeated again and again, with every imaginable variety of form and condition, in the perpetually varying cliff surfaces; and the mind thus gets bewildered with an infinity of detail, and unable to disentangle the several individual parts from such a network of confusion.

It can only be said, therefore, that we have in this mass of trap the following varieties of rock, without attempting to describe the exact order of their formation, or the exact mode of their occurrence:—

1. Contemporaneous feldspathic trap, more or less bedded and interstratified with the slates.

2. Feldspathic trappean ash, either hard and compact, or flaky and falling to powder.

3. Trappean breccia and conglomerate in a base of ash.

4. Intrusive feldspar trap, often not to be distinguished from the contemporaneous trap, except by its cutting across the beds; sometimes, however, having a much more crystalline character, and becoming a feldspathic porphyry, or even passing into a rock that can hardly be called anything but syenite, although the hornblende is either absent or rare.

5. Greenstone. This, so far as we know, is always intrusive; it is sometimes in the form of typical greenstone, a dense, dark-green,

compact stone, the crystals invisible to the naked eye, sometimes more coarsely crystalline, and sometimes very largely so, exhibiting a mass of confused crystals of feldspar and hornblende a quarter of an inch in diameter.

The last two rocks were sufficiently well known to all, but of the three first he would say a few words, as they were rocks not to be learnt by hand specimens, and only to be understood, and he might perhaps say believed in, by those who have long worked at them in the field. He might say this conscientiously, and from experience, because when he joined the Geological Survey of Great Britain, in 1846, he certainly doubted and disbelieved in the possibility of old beds of contemporaneous feldspar trap and their associated ashes and breccias being discoverable in these rocks. He spoke, then, now from experience, not gained solely or chiefly in Waterford, but also from some years' work in the mountains of North Wales.

1. Contemporaneous feldspathic trap is usually very fine-grained and compact, and would commonly be called compact feldspar. It has, however, here and there a little shining facet, showing a lurking crystal, and sometimes these crystals become even numerous. In a weathered surface of this trap it is not uncommon to see lines of little knobs and nodules that one at first takes for pebbles, and the whole rock looks at a distance like a coarse sandstone very regularly bedded, and containing thin bands of conglomerate. None of these nodules can be traced in the interior of the rock, but there is sometimes to be seen in it a set of coloured lines or bands, which are due entirely to what the Germans call "streckung," or stretching. We must suppose that the viscid, half-fluid mass, as it flowed along on being erupted, acquired a grain, as it were, or a regularly streaked character, from its own motion, as you might see in a mass of dough pulled out. Some of these bands became harder than others, and a first attempt at a nodular or concretionary form took place, not sufficient to be perceptible in the mass of the rock, but enough to show itself as the result of long-continued weathering.

2. Trappean ash. During some part of the eruption of the feldspathic trap, whether it were above or below water, we must almost necessarily suppose ashes and papillæ to have been ejected, and, falling in the water, to have formed beds of rock. If these were very fine-grained, and fell unmixed, they might form a hard compact stone, which a subsequent slight degree of temperature would so

bake that it should hardly be distinguishable from the trap itself, and when highly altered it must necessarily be absolutely indistinguishable. Sometimes, however, it was of coarser materials, and the stone is now composed of grains and flakes, and small angular or slightly rounded fragments of feldspar. It frequently contains, also, so much calcareous matter as to effervesce with acids, and sometimes it has in it the casts of shells and other organic remains.

3. Brecciated ash or ash conglomerate. In the year 1850 he met in North Wales with a very puzzling rock, and it appears that at the same time Mr. Willson came on the same at Waterford, at Newtown Head. It had a base of compact feldspar of a greenish-grey colour, with many large crystals of opaque white feldspar dispersed through it. He at first set it down as a porphyry, but in tracing it found the crystals of feldspar sometimes get as large as one inch or one and a half inches in diameter, that they were discoloured at their surfaces, and, although not perceptibly rounded, yet they were easily broken out and detached from the matrix. He afterwards, in tracing this rock, found it to contain angular fragments of feldspar trap, and eventually fragments of slate, and these sometimes in great abundance, angular fragments of slate and trap, several inches across, being mingled with smaller ones, more or less rounded, so that the whole became a coarse breccia. He then perceived that the small dispersed crystals of feldspar he had met with at first were not produced where they are now found, but were crystals that had either been washed from other rocks, or had been blown out of the orifice of the volcanic focus in the neighbourhood, together with the ash, and become imbedded in it on falling together into the water.

Now in Waterford there are abundance of these three kinds of rocks, more or less interstratified with small bands of slate and some larger ones, the whole pierced and traversed in every direction by great masses of subsequent and intrusive feldspar trap, and by equally large masses and numerous dykes of greenstone in all its varieties.

Above the principal mass of trap thus constituted, there is another large mass of black, blue, and grey slate, very sparingly fossiliferous, and in this are found occasional small interrupted beds of trappean ash, and small intrusive masses of greenstone.

The total thickness of Silurian rocks seen cannot be less, and may be more, than 8000 feet, inclusive of the traps, and 5000 feet

exclusive of them. They must be taken to belong wholly to the lower Silurian, nothing having been seen that either lithologically, or from its organic remains, could be at all considered likely to belong to the upper Silurian beds.

DEVONIAN FORMATION.—The lowest beds of the Devonian or old red sandstone formation consist of dull red sandstones and conglomerates. These conglomerates, when they form the actual base of the old red sandstone, are almost entirely composed of pebbles, and more or less angular fragments of those Silurian rocks on which they immediately rest. Higher in the formation the pebbles are principally quartz. Beds of red marl and of fine-grained red sandstone alternate with the coarser sandstones and conglomerates, and as we ascend in the series the fine-grained begin to preponderate over the coarser matters. Beds of yellowish or pale-grey sandstone likewise alternate with the red beds. These are often very hard and brittle. Ascending still higher, it usually happens that the red colour begins to disappear, or only occurs occasionally, and we then have beds of pale yellow or whitish sandstone as the *most prominent* feature of the upper part of the formation. This is the yellow sandstone of Mr. Griffith. On the north side of the county, between Waterford and Clonmel, this is a very persistent and uniform group of rocks. The thick-bedded, yellowish sandstones are very prominent, but between them, when a good section is found, are seen beds of shale, either red, green, yellow, or grey, and sometimes even a dark-grey. A greenish-yellow, very fine-grained flagstone is of very common occurrence in these beds. In the southern parts of the county, namely, on each side of Dungarvan Harbour, and down towards Ardmore, these upper yellow sandstones have these same characters. But as we trace them towards the west, namely, from Dungarvan towards Lismore, or from Ardmore to Youghal, we find the sandstones to diminish both in thickness and number, and the intervening shales to increase, especially in the upper part of the group, so that we finally have towards the west a set of beds on this horizon to which the term "yellow sandstone" becomes inapplicable, in a lithological sense, because they consist principally of a dark blue or grey shale, or, as it is almost always more or less affected by cleavage, a dark slate. This dark slate above the red beds of the old red sandstone, which is Mr. Griffith's carboniferous slate, is often scarcely distinguishable by any lithological character from the Si-

lurian slates below the old red. As, therefore, the terms "yellow sandstone" and carboniferous slate are thus likely to lead us into error, if generally applied, we should prefer to look on them as local terms only, applying accurately to certain localities, but generally it would be best to speak of the beds in the south of Ireland which intervene between the carboniferous and Silurian formation, as "Devonian," and to subdivide them into upper and lower Devonian. The upper Devonian would then include Mr. Griffith's yellow sandstone and carboniferous slate, which Mr. Jukes looked upon as contemporaneous beds, differing only in the materials of which they are composed, and the lower Devonian would be equivalent to the true old red sandstone.

The organic remains of these Devonian rocks are confined entirely to the upper division. They consist in the yellow sandstone of fragments of plants, in the carboniferous slate of marine shells. He believed from evidence, not gained in the district then under consideration, that we have in these two rocks a contemporary marine and fresh-water formation; that while the mud of the carboniferous slates was being deposited in a deep open sea on the S.W., and including thus marine remains, the sands of the yellow sandstone were being formed in the shallower waters of the N.E., along an ancient coast into which rivers and brooks emptied themselves, and brought down and deposited the remains of the land and of fresh water.

The thickness of the Devonian system in the south of Ireland will thus vary according to the circumstances of its original deposition. In Waterford he should state

The Upper Devonian as 700 feet.
The Lower do. 3000 ,, or upwards.

THE CARBONIFEROUS.—In the county of Waterford we have only portions of the base of the carboniferous system, namely, the mountain limestone, and those portions only the bottom beds of that subdivision, namely, the lower mountain limestone. This, in Waterford, as generally in the south of Ireland, consists of thick-bedded, light grey limestone, sometimes compact, sometimes crystalline, usually a more or less pure carbonate of lime, but sometimes containing a great quantity of magnesia, and becoming a true dolomite. At the base of the thick-bedded limestone, there is sometimes, *but not always*, a set of shaly beds, black shales alternating with thin

bedded flaggy limestone. These often pass down by such insensible gradations into the dark shales of the upper Devonian rocks that any line between them becomes a purely arbitrary one, and he believed that we often have a true passage or transition by insensible degrees from one formation into the other. Practically the best way is to take the lowest bed of limestone at any locality as the boundary of the carboniferous system, and to consider all below that as Devonian. In this way it is much more easy to draw a line between the carboniferous and Devonian systems, than it is to draw one between the upper and lower Devonian groups. The latter, indeed, sometimes becomes, *ex necessitate rei*, a purely hypothetical division, for the sandstones and shales, which in general are yellow or grey or blue, become in places all red, and the whole Devonian formation, in consequence, one homogeneous mass.

The Relative and Actual Position of the Rocks.—The appearance of the Silurian rocks at the surface is confined to the eastern half of the county of Waterford. They form a gently undulating, rather barren and rocky, but not a lofty tract, extending over nearly the whole of that part of the country. The strike of their beds is generally E.N.E. and W.S.W., the dip on the whole being to the W.N.W., at no very considerable rapidity of inclination. The beds, however, are greatly contorted, and roll and undulate in all imaginable directions, at all kinds of angles, so that single or isolated observations are of no value whatever, and the general position of the rocks is only discoverable after the whole country is examined. The calcareous bands of Tramore, after being perceived at intervals for six or seven miles, dipping N.W. under the traps, do not again re-appear in that direction. The broad band of the principal mass of trap, after disappearing under the slates to the N.W., likewise remains concealed underground, and does not re-appear, though the Silurian district stretches twelve miles further in that direction.

Upon the upturned edges of the Silurian rocks, and equally on the highest and the lowest of these rocks, rest the beds of the Devonian formation. On the western side of the undulating and contorted Silurian district stretches the bold range of the Comeragh mountains. These in their central part rise 2600 feet above the sea, consisting of at least 1500 feet of old red sandstone in nearly horizontal beds reposing on the Silurian rocks. They are broad, flat-topped hills, with wide swelling heathery moorlands that end

suddenly towards the east in grand precipices, with jutting capes and headlands, exposing sometimes nearly their whole thickness of old red sandstone in vertical cliffs, with merely a talus of fallen fragments at the foot. From this lofty central mass, the beds decline on either hand, both towards the north and south, at first very gradually, but at last, with a sudden dive, they plunge beneath the valley of Dungarvan and Lismore on the south, and beneath that of Clonmel and the Suir on the north. On this north side the beds strike east, with a mean dip of 30° to the north, as far as Waterford, just north-east of which they flatten and sweep round towards the north and south, on the one hand sweeping with the most symmetrical curve round the east end of the valley of the Suir, and running back to the west, along the north side of it, everywhere plunging under the flats of the mountain limestone; on the other, running in a broken and interrupted line down the sides of Waterford Harbour, and disappearing in the sea, south of Dunmore. That they continue under water a little south of the coast stretching from Waterford Harbour to Dungarvan is highly probable, and is made still more so by the fact of some small masses of old red sandstone being let in by complicated faults into the Silurian rocks of the coast near Bunmahon, where they may be seen in the cliffs, and are found in the mining operations at Knockmahon. The Silurian district, therefore is enclosed in a ring of old red sandstone, broken on the east, and concealed on the south by the waters of the sea.

On the west of the Comeragh mountains the old red sandstone stretches out in a broad, lofty, and barren district, and its beds are very shortly tilted up at steeper angles, and form the lofty peaks of the Knockmealdown Hills, some of which rise likewise to a height of 2600 feet above the sea. The outline of these hills is singularly different from that of the Comeraghs, considering that they rise to the same altitude, and are composed of the same beds. The Knockmealdowns are a narrow mountain ridge, with sharp conical peaks and a serrated outline, almost resembling a volcanic range; the Comeraghs are a great solid mass of land that would have been a great gently undulating plain, had not all the surrounding rocks been worn away, and this gnawed and indented lump alone left standing, like a pillar in an incomplete railway cutting, to show the amount of excavation around it.

The beds of the Comeraghs form one low arch of very gentle cur-

vature, except just at each abutment; those of the Knockmealdowns are frequently and rapidly undulated in very sharp curves. This undulation continues both north and south of them, as seen in Section 2;* and as the general level of the rocks declines on either hand, we get rolled in, first, patches of the upper Devonian or yellow sandstone, and then pieces of still higher rocks, namely, the mountain limestone. These undulations are in the form of long ridges and furrows, or synclinal and anticlinal curves, the axes of which run east and west, forming a succession of fertile valleys and bare broad ranges of high land over all the western half of the county of Waterford. There are four principal synclinal hollows, namely, that of Lismore stretching from Dungarvan to Fermoy, that of Tallow, that of Clashmore, and that of Ardmore. In each of these is a considerable thickness of mountain limestone; and generally we find that wherever the beds of the lower rocks plunge downwards at a sufficient angle and for a sufficient distance, a portion of the mountain limestone is brought in above them. We can, therefore, hardly fail to be convinced that the mountain limestone formerly stretched over the whole district, and has since been removed by denudation from all the loftier ground, those parts only being preserved that were enabled to nestle comfortably down into the hollows of the other rocks.

As regards the structure of the country he had only further to say, that several faults of very considerable magnitude had been discovered, and some of them apparently of great extent. These faults run north and south across the axes which mark the principal direction of the elevatory force The most remarkable are some near Ardmore and Whiting Bay. The latter half is bounded on each side by a fault, the downthrow of which is towards the Bay, the united action of these faults having been the very cause of the existence of the Bay.

The limestone of the two valleys of Clashmore and Tallow is cut off towards the east by a fault, which is an upcast towards the east of several hundred, perhaps a thousand, feet; and this fault is even traceable across the Lismore valley two or three miles to the east of Cappoquin. Parallel to it is another north and south fault, like-

* These sections will ultimately be published in the Section Sheets of the Geological Survey.

wise an upcast to the east or down to the west, that runs just west of Cappoquin, right down the valley of the Blackwater for some miles towards Youghal. Although the amount of its throw is not very great,—not so great as the faults on each side of it,—being not more than 520 feet, it is still highly probable that to this fault is due that very remarkable and sudden deviation of the Blackwater river, which at Cappoquin causes it to leave the valley it had hitherto traversed, and, instead of running out to the sea at Dungarvan, to run in a narrow ravine cutting right through all the ridges due south to Youghal.

He then briefly called attention to a few points in the history of the formation of these rocks, and of what has happened to them subsequently.

First, the volcanic agency had its most intense period of action about the middle of the time during which the Silurian rocks of this district were formed, but it did not entirely cease till long after that, as not only do we find here and there igneous rocks in the uppermost Silurian beds of this country, but on the coast near Bunmahon beds of the old red sandstone period have been altered and cut through by greenstone, and trap rocks show themselves cutting through the old red sandstone near Aughaviellia bridge, a few miles south-east of Clonmel, and near Ballynamult, half way between Clonmel and Dungarvan.

After the Waterford Silurians had been all formed, and before a single inch of the old red sandstone had been deposited on them, forces of disturbance had powerfully affected them, bending, contorting, and tilting them up, and bringing them within the reach of forces of denudation. These forces of denudation had so acted on them as to have worn and ground down the surface of the Silurian rocks to very nearly its present condition. They had, at all events, removed several thousand feet of strata, since we now find the beds of the old red sandstone reposing indifferently on the edges of the uppermost and lowest of the Silurian beds of Waterford, and we have already seen that the lowest must have once been covered by at least 8000 feet of slates and traps. We can hardly conceive of any other force of denuding agency than the action of the breakers at the surface of the sea, the wearing action of tides and currents for a comparatively short distance below the surface, and the very slow and trifling action of rain and wind, and the other atmospheric agents on rocks

when above the level of the water. To allow these agents to have produced this enormous amount of action we must suppose the Silurian rocks to have emerged very slowly into dry land, suffering to this extent in the operation. At the commencement of the old red sandstone period the Silurian rocks were certainly subject to the action of the breakers, forming banks of shingle and pebbles, which are now the old red sandstone conglomerates. It is probable that this took place during a period of depression, and that as the sea gained upon the land, each previous beach being now in deeper water, became covered with sand and protected, while the next was forming, and so on. From this it would follow, that where the highest bits of old Silurian land were in the old red period, those which were the last to disappear beneath the old red sea, that formation would have the least thickness; from this cause, if from no other, those spots would be the first to re-appear at any subsequent period, and are probably those where we now have Silurian rocks at the surface.

Round the borders of these districts, therefore, we may reasonably conclude the old red sandstone to be thinner than elsewhere, or in other words, we may suppose it to thicken as we recede from them.

When the Silurian rocks had become fairly plastered over with old red sandstone, the depression still continued, until, as we have already seen reason to conclude, the mountain limestone was spread out above it over the whole district. We have already seen that our lines of separation in the Devonian and carboniferous rocks are purely arbitrary, that there is every evidence of a gradual and successive accumulation of materials, without interruption or disturbance, from the bottom of the old red sandstone fairly up into the middle of the mountain limestone. Now we know that in the rest of Ireland and in Great Britain there is no appearance of any break or change having occurred from the bottom of the mountain limestone up to the very top of the coal measures. However startling it may appear at first sight, therefore, we ought to hold ourselves prepared to believe in the possibility of the whole of the coal measures having once extended in level sheets over the county of Waterford. Now the coal measures of South Wales are 12,000 feet thick, the mountain limestone of Tipperary and Kilkenny is 3000 feet thick, and we have already seen that the Devonian rocks of

Waterford are nearly 4000 feet thick. There is, therefore, a geological *possibility*, he did not say a probability, but a fair geological possibility of the Silurian rocks of Waterford having once been covered by 19,000 feet of other rocks, and of their having been depressed therefore at least that much below the level of the sea. If we halve that amount, and say 8000 or 10,000 feet, the possibility rises into a *probability*, because it is an absolute certainty that they have been depressed 4000 or 5000 feet, and that amount of strata at least accumulated upon them. This depression took place in such a way during the whole Devonian period, that it was probably greater on the S.W. than on the N.E., in which quarter there was still dry land, on which grew large ferns and other plants, with lakes or rivers of fresh water, and fresh water shells. It was continued, however, till even this land, if it still existed, became more remote, and the clear seas in which mountain limestone was deposited flowed over the whole country. Gradually these seas became shallower again, either by elevation or by filling up, sand and mud again prevailed in them, and coal was formed either below some shallow water, or, as is now more generally believed, a little above its surface. On the latter supposition we must suppose that the seas were filled up by the accumulation of materials while the depression still continued to operate, and thus the successive beds of coal became gradually buried one after the other.

At some subsequent period another elevation took place, and consequently another great denudation. This may have been a single and continuous operation, or it may have been distributed over the whole lapse of time from the close of the coal measure period down to our own days. That a large part of the denudation, however, is of early date is rendered probable, if we look across the Channel, and compare the geological structure of the south of Ireland with that of South Wales and the south-west of England, for it would appear highly probable that as the formation of the rocks was contemporaneous in each place, so were the parallel lines of disturbance (both running east and west) likewise contemporaneous. In Britain we know these disturbances and the consequent denudations were brought almost wholly to a close before the deposition of the higher beds of the new red sandstone. We may therefore assume the same period for those that have affected the south of Ireland.

He must, however, utter a warning against M. E. De Beaumont's theory of the cotemporaneity of parallel lines of elevation being carried too far. In the British Isles alone we have three cases of east and west strike which have been communicated to rocks at three widely different epochs. In North Wales the whole of Denbighshire is occupied by Silurian rocks that strike east and west, traversed by a multitude of east and west anticlinal and synclinal lines, every one of which was produced before the Devonian period, since the old red sandstone and mountain limestone lie flat across the edges of the beds, and strike north and south. In South Wales and west of England, and, if we rightly believe, in the south of Ireland, the east and west strike was communicated to the rocks after the close of the coal measure period, and before that of the upper part of the new red, probably, therefore, during Murchison's Permian period. In the south of England again, in Isle of Wight, and in the Weald of Kent, the east and west strike was given to the rocks there after the formation of the chalk or during some tertiary period.

April 14, 1852.—" Remarks upon the Geology of the Vicinity of Ballyshannon;" by ROBERT CRAWFORD, Esq.

THE principal rocks occurring in this neighbourhood are carboniferous limestone, sandstone, and mica schist, passing into gneiss.

Among these, the limestone occupies the most conspicuous place, being of greater extent than the two latter formations taken together. It is generally of a dark blue colour, fine in texture, extremely hard, and in most places highly crystalline. It is much used here as a building stone, and is very durable.

At Bundoran, about three miles to the south-west of Ballyshannon, the limestone appears along the banks and on the shore in shelving rocks jutting into the sea. These abound in fossil shells, &c., so that in some places they seem entirely composed of them. Here also, numerous white veins of calcareous spar appear traversing the rock in the direction of the dip. To the north-west of Ballyshannon, on the shore near the Old Abbey, a vein of zinc blende occurs, but as it is now covered with large loose stones, my time

was too limited to examine it minutely. This neighbourhood is also extremely rich in fossils.

The next rock in order of extension is sandstone. It is of a yellowish grey colour, even texture, and in some places where it is exposed it is very hard, so as to strike fire with steel. This formation occurs in two distinct places, at Bundrowes, on the border of the County Leitrim, and again at Kildoney Point, to the north of the entrance to Ballyshannon Harbour. In both places the stone is perfectly similar in appearance. Notwithstanding a very close examination of this for some days, I was unable to find any *fossils*, or even the *traces* of any organic remains in it, except a few imperfect impressions of plants.

In one place I found it overlying the limestone, both having the same dip, and apparently conformable. Nor was there any great appearance of disturbance, such as could have thrown them into the position here described (were it not their natural one).

Besides, the dip of the sandstone at this particular spot corresponds very nearly with its general direction in all the surrounding district. From this I would infer that the position held by these rocks in this instance is their true relative position with regard to age, and that the sandstone is the newer formation of the two.

Again, at Bundoran the limestone has a general tendency to dip towards the south-west, while the sandstone to the south of this point, *at a much higher level*, dips in pretty much the same direction. This, I think, strengthens the opinion I have already given with regard to the relative ages of these two rocks.

At a quarry at side of road leading from Bundoran to Kinlough, the sandstone alternates with a greenish rock, rather slaty.

At the town of Ballyshannon, and in something like the shape of the letter V (the point being next to the sea), mica passing into gneiss occurs. It is very hard and massive, and not nearly so fissile as mica schist. The dip is uncommonly well marked in many places, and the junction of this rock with limestone on both sides is visible. This rock goes by the name of *whinstone* among the labourers, on account of its toughness.*

* Vide Section 2, Pl. 2.

May 12, 1852.

Mr. Hamilton exhibited a section of the cutting on the Drogheda and Navan Railway, south of the Beaupârc station. The object of it was to illustrate the contortions of the calp limestone, which is here finely bedded, among which there are two beds, 5′ and 1.5′ thick, of crystalline limestone. He remarked that there was evidence of two kinds of disturbance, one of an upward force, which has heaved up both the calp and crystalline beds: the other, a horizontal force, which has twisted the calp, the direction of which was about in *the line of section.*

These contortions are visible along a line perpendicular to the line of section for some distance.*

June 9, 1852.—"Notes on the Geology of the Country about Kingscourt;" by John Hamilton, Esq.

The part of the country described by Mr. Hamilton, and of which a map and section were shown at the meeting,† is a district which has for its central point the junction of the Counties Meath, Cavan, and Monaghan. The general features are:—The calp, or dark shaly limestone, covered with gravel hills, particularly towards its northern extremity; it is bordered on the N.E. and S.W. by the mountain limestone, which rises into rugged rocky hills; from these hills the coal measures and new red sandstone fall to the base of the high hills of Silurian slate which bounds the district to the west.

Beginning with the calp or black limestone, which occupies an extensive tract, its general dip is, I think, to the N.W., but as it is everywhere very much contorted in places where I observed the dip, it read N. and E. of N., and even E. of S. It is everywhere intersected with veins of chert.

Associated with the calp is another formation, which assumes very different appearances in the two places where I observed it. In the first of these it is a sandy shale exposed in a glen through the

* Vide Section 3, Pl. 3. † Vide Section 4, Pl. 4.

calp; it seems to lie conformably to the latter, though at a higher angle, both it and the calp, at the nearest point of observation, dipping to N. 25° W. In the second place, it is a fine-grained, finely stratified sandstone, which varies very much in hardness, sometimes becoming a friable white mass. This is visible in mass only in one place, where it dips W. 9° N., at an angle of 35°, but traces of it are visible near its limits, where it seems to have joined the calp, and in these places it is *distinctly interstratified with the calp.* It is intersected with veins of chert exactly like the calp, and seems, when in a soft state, to have shared with it the influences which have contorted it as the calp is. It seems that at one time it had a much greater extent, and that it has been worn away by denudation, both from the surface it presents, and also from the fact that the gravel hills are full of fragments of the same kind of sandstone and bits of chert, mixed with pieces of calp and mountain limestone. This formation, then, belongs to the grit beds of the carboniferous limestone, and in this instance is associated with the calp division of that system. In tracing the black limestone up a glen in the bed of the stream, and in ground on each side, there are several nodules of various sizes which have been worn by the stream out of the calp. As I could not find more than one *in sitû*, I cannot say whether they are distributed in layers in the calp; but some are found of an appearance as if once joined together, like grape-shot. The constituents of these nodules are the carbonates of lime, magnesia, and iron, in the following per-centage: 68.64 per cent. of carbonate of lime; 2.64 per cent. of carbonate of magnesia; and 5.60 per cent. of carbonate of iron; the remainder being made up of silex and iron pyrites, which fills the columnar divisions of the stones.

100 grains gave—

Insoluble Matter.

Silex and Iron Pyrites ($Fe\,S_2$) + loss, . . .	23.12
$Fe\,O, C\,O_2$, ...	5.60
$Ca\,O, C\,O_2$, ...	68.64
$Mg\,O, C\,O_2$, ...	2.64
	100.00

At this point the valley is crossed by a ridge of a fine-grained crystalline greenstone; the mass is about ten feet thick at the surface, and is visible for 30 yards, running W. 30° N. This intru-

sion changes the dip of the calp at the spot, causing it to form a synclinal. Further up the valley there is another mass of the same, running W. 34° N. The next formation is the mountain limestone, which forms rugged hills, covered with large masses of the stone, which have been greatly water-worn. Its general dip is a few degrees *south of west*, and at an angle of from 10° to 20°, with *very distinctly marked joint planes*, which run N. 25° E. throughout the whole mass. It is in many places highly fossiliferous,* but in one part it becomes destitute of fossils, and hard and highly crystalline, almost a marble, though I cannot account for its being so highly crystalline in this point. In the middle of the limestone (near Breslaustown) one of the forms which it takes is in a thick bed which is a brecciated mass, and appears as if formed of angular pieces of limestone, cemented together by the pouring in of large quantities of sandy carbonate of lime.

The mountain limestone is succeeded on the east by a gritty sandstone. The change is a gradual one, the limestone gradually becoming more sandy till it becomes a perfect sandstone. This is another form of the grit beds of the carboniferous limestone, in this case associated with the crystalline beds of it.

Overlying the mountain limestone comes the coal measures, which in many places rise up, forming a cliff to the S.E., where I observed it and the limestone close together. They were conformable, though at a distance it is not so. They dip at an angle of 26°, and have very distinct joint planes running in the same direction as those in the limestone. It varies in character very much, from a compact red and white freestone to a loose, sharp, siliceous sand. In many places it contains impressions of stalks, and thin beds of coal and coaly matter. The place where I observed the latter more particularly is in a cutting of a stream, forty feet deep, to drain a lake. Between the limestone and the sandstone there were:—1st, stiff clays; 2nd, thin seams of coal and coaly matter; 3rd, friable variegated shale; and this order was repeated over and over again. At one point there are, interstratified with the coal sandstone, three beds; the upper one of these is a bed two feet thick, of an impure calcareous sandstone, the middle one a bed one foot thick, of a black

* Containing the genera Euomphalus, Bellerophon, Spirifer, Loxonema, Cypricardium, Productus.

fissile shale; and the lowest a bed five feet thick, the same as the upper one. The middle bed is full of impressions of shells, and some traces of plants, which seem to have all suffered great compression, being greatly flattened out. The shells belong to two genera, Goniatites and Pecten. The trough formed by the slate hills and the inclined sandstone beds is filled with red and blue loams and marls, and stiff plastic clay of the new red sandstone formation; in the centre these are horizontal; but at the edges it seems to dip, so as to take the form of the trough in which it lies. In one place, as far as I observed, there are several beds of gypsum, separated by thin beds of plastic clay. By boring they have ascertained that these beds are forty feet thick, at least; but no traces of salt beds are found either from boring, or in the springs of the district.

The high hills to the east stretching northwards are formed of green Silurian slates standing at a very high angle. They separate into very thin laminæ, the divisions being made in the planes of stratification, and not in those of cleavage; the divisions in the direction of cleavage are filled up and cemented together again by seams of carbonate of lime. They dip on one side of the hills to the S. 26° E., and over the hills to N. 35° W., appearing to form a very high anticlinal axis. At the base of these hills there is generally a talus of coarse gravel, formed of water-worn pieces of the Silurian.

ANNUAL ADDRESS

OF

THE PRESIDENT,

LIEUT.-COLONEL PORTLOCK, R.E.

DELIVERED FEB. 11TH, 1852.

GENTLEMEN,—In addressing you on this occasion I shall adhere to the system which I adopted in my Address of last year, and divide the subject of our researches and studies into the two branches of Physical and Organic Geology.

In the first of these branches it may appear to many that we are restricted to the examination of our own planet, and that it would be vain to look beyond the limits of the earth itself for any information calculated to throw light either on its structure or on the phenomena exhibited in the various dislocations and disturbances of its surface; but though it would undoubtedly be unwise to base our science on observations drawn from the external planetary bodies, or to resume those cosmical dreams which led the early cultivators of natural science into the field of dazzling but useless speculation, it is assuredly only right to ascertain whether the conclusions we have drawn from terrestrial observations alone are in conformity with the laws which regulate the combinations and the condition of matter throughout the universe. If, indeed, we investigate laws rather than isolated facts, we perceive that there is every reason to believe that they are general and not local; that they are not limited to the earth itself, or local, but are in equal operation throughout the visible universe. And it is thus, for example, that with each fresh discovery of a new planet, there is obtained additional proof of the universality of the great law of gravitation. Keeping, then, in view the great probability, at least, of uniformity in the laws of nature, we

are justified in applying the knowledge acquired of other planetary bodies to the rectification of anything which is imperfect in that of our own. In studying the earth with a view to the elucidation of the phenomena exhibited by its surface, it has, for example, been found necessary, or at least it has been thought necessary, to assume that the planet was once in a liquid state, that the cause of its fluidity was original heat, and that a portion of the crust has cooled down, and become solid, in proportion as this heat has been radiated into space. According, therefore, to this hypothesis, it is supposed, that some portion of the earth is still in a liquid state, either as a central nucleus, if the consolidation has commenced from the surface; or an intermediate annulus, if the consolidation has proceeded simultaneously from the centre and surface. This hypothesis has been principally maintained on two leading arguments; namely, the evidence of internal heat, and the coincidence of the form of the earth with that which would be assumed by a fluid body rotating upon its axis, in the manner of the earth.

Before, however, I enter on the latter consideration, let me notice an independent objection which has been urged against the theory of a still existing liquid nucleus by that eminent philosopher, Mr. Hopkins, now President of the Geological Society of London, namely, that under the very great superincumbent pressure of the superficial mass a condition of liquidity is impossible. To maintain this objection it seems to me necessary to establish what are the actual conditions of fluidity. One of these is manifestly a temperature, definite as regards each substance under some one fixed pressure, and another a definite pressure, estimated as regards some fixed temperature. But there is another condition which must materially affect the change from a liquid to a solid, or from a solid to a liquid state, namely, the mode in which the particles of the body are arranged when they assume a crystalline form.

Let me, for example, inquire how these conditions may be supposed to affect the great mass of water which forms an envelope to so large a portion of the earth. Water, then, is known to us in three different states: as vapour in steam; as a liquid in water; and as a solid in ice. The change from the liquid to the gaseous or vapourous state can be examined in reference to the conditions both of temperature and pressure, and it is found that as the pressure increases the temperature must also increase, in order to effect the desired

change, or to transform the liquid water into the gaseous steam, and it is therefore possible to conceive that a pressure might exist more than equivalent to the effects of any conceivable increase of temperature. But what is the state of the case, if we examine the other change, namely, that of the liquid water into the solid ice. If this change take place by abstraction of caloric or by congelation, M. Person has shown that there is an intermediate state in which water resembles a viscous rather than a fluid or solid mass. It is in this state that water, contrary to the usual effect of increasing cold, begins to expand by a re-adjustment of its molecules, until at length it becomes a crystalline solid in ice, which occupies more space than the fluid water, and is therefore specifically lighter. What, then, should be the effect of an alteration of pressure on this remarkable change? It might be supposed that a diminution of pressure ought, so far as regards the expansion or crystallization, to facilitate freezing, or to raise the freezing-point, and an increase of pressure ought to restrain it; but though the latter must be the case, there does not appear any means to establish a balance, as diminished temperature would only lessen the power of the body to assume a more bulky form, or to resist the compression of pressure. Nor, indeed, can even the first proposition be admitted, as expansion from temperature may take place without the assumption of a crystalline condition.

Is it, then, possible that water may be solid and not crystallized? So far as our knowledge at present extends, I am not aware that this question can be otherwise answered than by a negative. The sounding-line has penetrated depths of an ocean amounting to about two miles, or 3500 yards, and though the temperature has been found little above the freezing-point, a state of perfect fluidity has been preserved, though under a pressure of more than 100 atmospheres, and there is little reason to doubt that the result would be the same at the probable extreme depth of our ocean, or under a pressure of 200 atmospheres. We see, then, that the change from the liquid to the solid state depends in water on peculiar molecular properties or relations, which are in some degree consequent on a particular state of the body as regards caloric. In other substances the effects of the changes from a liquid to a solid, or from a solid to a liquid state, may be less striking; but I am not aware that any experimental evidence can be adduced to show that when a body has

assumed a liquid state, to which certain molecular arrangements are essential, that it can, by pressure alone, or without the loss of caloric, be restored to the solid form.

At the present time Mr. Hopkins is engaged in a series of experiments, at the instance of the Royal Society, on this most important and interesting subject; and, aided by the great mechanical ability of Mr. Fairbairn, there is little doubt that he will ere long arrive at a determination of the limit, if such there be, in masses of mineral matter, where the repulsive force, either exercised by, or called into action by, caloric shall be infinite as compared to the compressing force of pressure, and where fluidity must therefore be permanent, so long as the temperature remains unchanged.

Having thus briefly stated the doubts I at present entertain as to the possibility of reducing to a solid state, by pressure alone, the molten mineral matter of our earth, so long as a sufficiently high temperature can be maintained to insure an adequate repulsive force, I shall proceed to the other objection which has been urged by our able Secretary,—namely, that *all* the planets do not exhibit forms which a fluid rotating upon its axis ought to assume. It would be out of place to repeat here the mathematical reasonings on which Mr. Haughton rests his objections, as they have formed the subject of a detailed paper read before the Royal Irish Academy; but the general character and results of that reasoning I shall now briefly state.

Mr. Haughton, starting from the celebrated theorem of Clairaut, which expresses the results of the combined actions of gravity as an attractive, and of centrifugal force as a repellant force, in a body rotating on an axis, first inquires whether the figures of the several planetary bodies, of which tolerably accurate measurements have been made, fulfil the necessary conditions of that theorem on the hydrostatic or fluid theory. Stating the maximum and minimum limits of the compression which fluid bodies of the magnitudes of the planets should exhibit, Mr. Haughton finds that the compression or ellipticity of Uranus, of Saturn, of Jupiter, and of the Earth, is consistent with the theory of original fluidity, but as regards Mars, that the result is widely different. For example, whilst the major theoretical limit of ellipticity is $\frac{1}{258}$, and the minor limit of ellipticity is $\frac{1}{644}$, the measurements by Herschel (1784) give the polar diameter, 1272, and the equatorial, 1355, or an ellipticity of no less than $\frac{1}{16.32}$.

Hence, if it be assumed that in all cases the liquid mass of the planets had arrived at a state of equilibrium before consolidation, or that, being still fluid, it is in a state of equilibrium, this ellipticity must be considered inconsistent with the conditions of the theorem, and hence a fluid theory will be inadmissible.

Before, however, I further examine this portion of the argument, or discuss the data on which it depends, let me look at the other form of the proposition—namely, original solidity. Reasoning, then, from these two postulates, which are considered observed facts,—namely, first, that gravity is perpendicular to the surface of the earth; and second, that the figure of the earth is that of an ellipsoid of revolution of small ellipticity,—Mr. Haughton shows that the conditions of the theorem of Clairaut are fulfilled by the earth, on the hypothesis of original solidity, and further, that the deduction may be generalized so as to embrace the other planets, including Mars. "It thus appears," he says, "that the theorem of Clairaut, which establishes a connexion between the law of variation of gravity and the figure of the earth, is independent of the fluid hypothesis, and even of any very definite hypothesis, as to the arrangement of matter in the interior of the earth."

So far, indeed, Mr. Haughton appears to avoid, or at least imagines he has avoided, hypothesis; but the difficulty, if not impossibility, of so doing is made manifest by the next passage, where he says:—"The distribution of the materials composing the planets must be such as to satisfy" an equation in which "the difference between the moments of inertia of the earth round the polar and equatorial axes enters as a function of its figure and rotation." It appears to me that this is as great a difficulty in a philosophical solution of the question as can well be conceived, for whilst on the fluid theory the result of rotation of a spherical body is, that it shall assume a compressed figure, and that the force of gravity shall continue perpendicular to the surface, and the figures of all the planets measured with sufficient precision, excepting one, conform to that theory, both in rotation and figure—it is necessary to assume, on the theory of solidity, such an arrangement of the materials as will produce this perpendicular action of gravity; and in the case of Mars, to modify this assumption by another perfectly arbitrary,—namely, "to suppose that Mars contained originally more or denser matter in his equator than the other planets," a supposition which seems to be

at variance with the harmony of nature, and to rest on no reasonable ground. But may we not also ask whether this latter supposition is consistent with the first postulate,—that gravity is perpendicular to the surface? and further, though the mean or average result on the earth may be assumed as a perpendicular direction of the force of gravity to the surface, are there not sufficient local deviations and disturbances to show us that the generality can only be due to equally general regularity of distribution in the matter of the earth? Admiring, therefore, as I do, the mathematical powers of our learned Secretary, I cannot admit that he has as yet satisfactorily solved this great cosmical question; and I shall for a moment turn again to the consideration of the fluid theory.

Mr. Haughton adopts the measurements of Herschel in respect to Mars; but, as pointed out by Mr. Hennessy of Cork, another distinguished mathematician of our College, these measurements have not been adopted by modern astronomers. Laplace* adopts Arago's measurements, the two diameters being in the proportion of 189 to 194, and Schubert† gives the measurements of Schröter, which afford a ratio of 81 to 80, though he also quotes those of Herschel. It thus appears that the following proportions between the polar and equatorial axes have been given by independent observers, namely:

1.0667,	or ellipticity,	$\frac{1}{16}$
1.0265,	"	$\frac{1}{39}$
1.0125,	"	$\frac{1}{81}$

which exhibit a very remarkable discrepancy, and although the results are all in excess of the theoretic compression, I cannot admit that, in consequence, it must be assumed that the fluid theory has failed. These figures alone do not even convey a sufficiently powerful representation of the uncertainty which still hangs over the determination of the real figure of Mars.

Humboldt, in the third volume of Kosmos, gives two independent determinations by Arago,—the first, $\frac{1}{38.8}$; the second, $\frac{1}{32}$. An eminent Cambridge mathematician thus writes:—" Before speculating as to the cause of the large ellipticity, it is proper to inquire, does it exist? On taking down a volume of the Greenwich Obser-

* See Harte's Translation, vol. i., page 57. 1830.

† Traité d'Astronomie Theorique, tome ii. page 258.

vations, and referring to it, it seemed that the discrepancies between individual observations were larger than the whole quantity in dispute." Professor Challis has even furnished me with two determinations of the ellipticity of Mars, from distinct sets of Greenwich Observations, and whilst these differ as widely from each other as the least and greatest do of these I have quoted, the mean gives a compression of $\frac{1}{68}$. Again, Mr. Hind, in his most beautiful popular work, "The Solar System," after mentioning the statement of Sir W. Herschel, observes:—"But an extensive series of observations recently taken with the best instruments to be found in observatories, gives the compression much less, or the ratio of the diameter, as 51 to 50, which is probably nearer the truth. It is only at the oppositions, or about once in two years, that we see the disc of Mars fully illuminated; consequently, the proper times for determining the difference of diameter, or for any observations upon the appearance of the surface, are not of very frequent occurrence." The rarity of such opportunities, and the great difficulty of determining a difference between the diameters of a planet which subtends an angle of little more than four seconds at the time of conjunction, and while in opposition and perihelion somewhat more than thirty seconds, have, doubtless, led to such conflicting statements,—as the error of a single second, which may reasonably be expected in such observations, would involve more than the whole expected difference. Nor is it surprising that Dr. Maskelyne could detect no sensible difference between the equatorial and polar diameters, and that Professor Johnson, of Oxford, has furnished me with a result tending in an opposite direction. He gives his observations with reserve, and does not attach much weight to them, having been taken at the early period of his connexion with the Observatory; but they are, at least, additional proofs of the great difficulties and uncertainty of the subject:—

1850.	Equatorial Diameter.	Polar Diameter.
January 4,	5.562	6.441
„ 5,	6.145	7.186
„ 7,	5.932	„
„ 13,	5.967	5.881
Mean,	5.901	6.503

The planet was at its mean distance from the earth, and Professor

Johnson observes:—"You see I make the polar diameter exceed the equatorial. Most probably this arises from error of observation, for at best I find it a difficult object."

To me this great discrepancy proves either that, owing to the small size of the planet, one-half that of the earth, no correct measurements have yet been effected, or that there are circumstances connected with its appearances, and even, perhaps, with its substance, which render such determination difficult and dubious; or finally, that Mars has not yet attained a state of perfect equilibrium,—for we may suppose* "that according as compression increases, the motion of rotation will become less rapid; therefore, if there exists between the molecules of the fluid mass a force of tenacity, this mass, after a great number of oscillations, may at length arrive at a motion of rotation comprised within the limits of equilibrium, and fix itself in that state."

Mr. Harte, in his very able notes on Laplace, points out, as Mr. Haughton has done, the two limits within which the compression of a planet should be comprised; and in applying the rule to the Earth and Jupiter remarks, that Laplace had deduced from it an increase of density in Jupiter, from the surface to the centre, just as the observations made on the density of the earth have established to be the fact in our own planet,—a very striking analogy, which may well be added to the many other examples of harmony in the works of nature.

I think, therefore, with such great discrepancies, sometimes rising, and sometimes sinking in amount, I am justified in believing, either that the compression of Mars has never been accurately determined, or that it is variable. But the first of these suppositions is strengthened by the uncertainty which even yet hangs over the compression of Jupiter, the apparent diameter of which is double that of Mars. Humboldt† gives the following measurements of ellipticity, namely, by Arago, in 1824, $\frac{1}{17.7}$; by Beer and Mädler, in 1839, between $\frac{1}{18.7}$ and $\frac{1}{21.6}$; and by Hansen and Sir John Herschel, $\frac{1}{14}$; and if with a planet so large, and which exhibits so clear a light, accompanied by a well-defined outline, it be difficult to determine the compression, well may there be hesitation in depending

* Harte's Notes on Laplace, vol. ii. page 455.

† Kosmos, vol. iii.

upon the determinations as yet recorded, either of the time of rotation, or of the compression, or of the mass of Mars.

Whatever may have been the original state of Mars or of the Earth, I think there can be little doubt that the latter has passed through (in great part, if not as a whole) a condition of fluidity; not, indeed, of such a perfect fluidity as is exhibited by water, but rather in the case of ordinary earthy or mineral matter, the fluidity of a viscous mass, such as is actually observed in the erupted lava of volcanoes. The occurrence of rocks, which by their crystalline and yet compound character must have required the action of some solvent in all parts of the globe, seems to require a cause possessed of equal generality; and though that cause, or the medium of solution, cannot have been water (as appears to have been the opinion of Laplace), there is no apparent objection to the efficiency and generality of heat, whilst such a cause explains most simply the generality of the so-called igneous rocks, and its still continued action, the phenomena of volcanic eruptions. It is true, indeed, that a modern philosopher of the highest eminence attributes volcanic eruptions to the pressure of elastic gases in the surface of internal lakes or reservoirs of melted stony matter, which in his opinion are local, and have no connexion one with the other. But if so, how can the generality of such phenomena be accounted for? Taking into our consideration the trachytic and basaltic eruptions of ancient but well-defined volcanic vents, the vast basaltic flows of submarine volcanoes, the numerous basaltic and other dykes which must have proceeded from molten masses within the crust of the earth, which they have riven asunder,—how can we account for them as merely local and partial? If progressive, how can we imagine that the cause of fluidity should have shifted from place to place, until it had, as it were, spanned the whole earth; and if simultaneous they become general.

The arguments which have been advanced for this partial existence of volcanic reservoirs are these:—The supposed impossibility of a liquid nucleus or liquid annulus in the interior of the earth, under so great a superincumbent pressure; and secondly, the want of any sympathy, as it were, between the eruptions of distant volcanoes. The first I have already discussed, endeavouring to show that the condition of liquidity may be preserved under any pressure; and if I am right it must be manifest that whenever, by a dis-

location of the crust, a local relief of the pressure takes place, the liquid matter within will be ready to yield to the lateral force, and to rise up into the fissure or crack above it. Such, indeed, would be the case, even were there not an actual condition of fluidity, if pressure alone prevented the assumption of that condition, as on the removal of the obstruction the matter condensed would at once become fluid, and nearly the same phenomena be exhibited. In regard to the second objection, it is manifest that the propagation of motion through a body so imperfectly fluid as the molten earthy matter of our globe necessarily is, must be a very slow process, more especially as frequent subsidences from dislocations must occur to check it. The eruption of a volcano may therefore be, and in all probability is, the result in many cases of pressure at a very distant point slowly propagated through the viscous mass, and terminating by an outburst of molten matter, long subsequent to the first impulse which really produced it; and in like manner, the earth-wave, or earthquake, being propagated with greater rapidity through the solid medium of the crust, it may have passed away long before the occurrence of an eruption, the origin of which was actually at the same point and time. It is thus that in my mind the actual earthquake and volcanic phenomena are really connected with each other, their origin being synchronous, though their visible results are not so.

Were it possible to remove the envelope of detritic matter which conceals so large a portion of the probably congelated crust of the earth, it would be easy to estimate the disturbances which it has experienced; but it is now seen only darkly through a veil. Let it not, however, be supposed that the degrading force of water has materially assisted in giving its present form to our earth, as Mr. Haughton supposes it may have done in Mars; for though the sedimentary deposits have been contorted and elevated by internal convulsions, they are in themselves, even including the metamorphic or crystalline schists, a small fraction of the earth's crust in thickness; and when compared with the augmentation of the earth's semidiameter, if we allow them a thickness of five miles, they are but one-half of the difference between the polar and equatorial radii. But, further, let it be also remembered that there are sedimentary deposits in all parts of the world, and it is therefore more than probable that if the action of water has preserved a proportionate increase in thickness of these deposits from the poles to the equator,

it is the utmost effect which can be ascribed to it; and hence, that the real form of the earth had been acquired before the work of degradation had commenced.

In addition to the arguments for a former condition of igneous fluidity of our earth afforded by the wide, or rather general, extension of crystalline massive rocks, and of trachytes, basalts, and other volcanic rocks, as well as by the progressive increase of temperature from the surface of the earth downwards, the existence of insulated crystallized minerals in the heart or substance of rocky masses appears to supply another most important one. Our able member, your former President, Mr. Mallet, has shown us how effectively the experiments of the laboratory may be made the basis for establishing great physical laws, in his researches on earthquakes, or on the transmission of waves through solid media of various degrees of elasticity; and in a similar manner M. Ebelman has illustrated in the laboratory the formation of many of the hardest and most infusible of the precious gems. In my former address I pointed out the researches of M. Daubree on the formation of quartz crystals, &c., through the intervention of chlorine, and the re-action of some other base on the volatile chloride of silicium, using that compound as a substitute for the natural and less easily formed volatile compounds, fluoride and boride of silicium; and there cannot be a doubt that many of the crystals in veins, or which line fissures or cracks, have been thus formed, as there is no appearance of a corresponding action of heat on the containing substances; but these are, to a certain extent, secondary or subsequent to the formation of the sedimentary deposits in which they occur; and though they betray, to a certain extent, some remarkable peculiarities of the internal portions of the earth, they cannot entirely explain the formation of definite crystallized minerals.

About four years ago, M. Ebelman described, in a paper read to the Academy of Sciences, his views of crystallization in the dry way, in which the elementary substances are held in solution by a mineral solvent, aided by great heat; and exhibited some of its most striking results in artificially formed gems. In a second paper* he has now still further illustrated the subject, and formed many rare and precious stones, which, though infusible at the temperature of our

* Read March 3, 1851. Annales de Chimie, Sept., 1851.

furnaces, are found naturally formed in the mineral kingdom; and further, by thus preparing some new crystallized mineral compounds analogous to known species, he has generalized his discovery, and furnished types to which the composition of these species also may be referred. Ebelman proceeds on the same principle as if he had adopted water, alcohol, or even fluorine or borine, as a solvent, selecting, however, a substance which remains fixed at a high temperature, though at a higher it becomes volatile,—such as boracic and phosphoric acids, and some alkaline phosphates. These substances act as powerful fluxes at a high temperature, but are ultimately vaporized, when the substances they retained in solution crystallize. Some of the examples of his last experiments I shall here state. *Zinciferous Spinelle or gahnite*.—In his various trials M. Ebelman found the zinc volatilized in great measure by the heat of the porcelain furnace he used, and hence he failed to produce the required mineral. He now used the muffles of M. Bapterosse's manufacture of paste buttons, and succeeded. A mixture of alumina, 6 grammes; of oxyde of zinc, 5; and of melted boracic acid, 6;—exposed in the muffle for eighteen hours, left crystals of aluminate of zinc, which scratched quartz easily. They consisted of—Alumina, 55.9; oxyde of zinc, 44.1, corresponding to the formula, Al_2O_3, ZnO. And in another experiment, in which a little bichromate of potash was added to the mixture, beautiful transparent octahedral crystals of a bright ruby colour were obtained, some of which measured one-tenth of an inch the side. Cymophane, or aluminate of glucine, was formed in transparent crystals, which scratched topaz, and in length were from 2 to 2½ tenths of an inch, the specific gravity being 3.759; whilst that of the native cymophane of Brazil is 3.734. This mineral, therefore, could be prepared sufficiently large for the cabinet of a mineralogist. Chromates, ferrates, and magneso-borates were similarly formed; but let me turn to silicates. Peridot, or silicate of magnesia, resembling that of Vesuvius, was formed from a mixture of silica, 4.50 grammes; magnesia, 6.15; boracic acid, 6.00, the result being a composition corresponding to the formula,—$Si O_3, Mg O$; or silica, 42.6; magnesia, 57.2; with traces of oxyde of iron. These crystals had the vitreous lustre and hardness of native peridot, and *were infusible* by the blow-pipe; their density was a little less, as they contained less oxyde of iron. Alumina was obtained crystallized, with all the properties of corindon (corundum).

It is unnecessary that I should follow M. Ebelman through all his labours, or give the entire list of the minerals he produced. But one passage in respect to aluminates deserves especial notice:—"If the metallic borate is fixed, and if the affinity of the alumina for the base is not sufficient at the temperature of the furnace to expel the boracic acid combined with it, the alumina crystallizes in a state of purity in the midst of the fluxed matter, whether borax and silica, borax and barytes, lime or oxide of manganese; and if the affinity be sufficient, aluminates of the several bases are formed. How strong is the resemblance of this first case to that of the crystallization of felspar in a more fusible felspathic paste, so common in porphyries."

M. Ebelman observes with justice, that by this beautiful process the chemist is able to establish the true types and formulæ of mineral species, as the specimens he produces are in a state of purity, which can rarely be the case with native minerals; and thus to introduce a greater precision in the grouping of such species; and, acting on these results, he unites the diallages with the hornblendes. Well may M. Ebelman say—"That by such researches we shall obtain much valuable notions of the origin and conditions of crystallization of mineral species;" and, I will add, an illustration of the real condition of the matter of the earth in which such processes have been carried on.

To this description of inquiry I attach all those investigations which lead to the recognition of general action, whether chemical or physical, as they must in the end afford us a more correct knowledge of the manner in which the earth has been brought to its present state. I have before dwelt at some length on the labours of M. Delesse in this branch of what may be called chemical geology; and have shown the bearing of M. Rammelsberg's researches on the same question. Mr. Haughton has entered on the same field with the latter chemist in his comparisons of the serpentine of Cornwall and Connemara, being aided in his analysis by another of our members, the Rev. Mr. Galbraith. From careful analyses of a Cornish specimen, and of one from Ballinahinch quarry in Connemara, it appears that their composition is conformable to the formula deduced by Rammelsberg from a mean of thirteen results from different localities,—viz.:

$$2\,[(3\,MgO,\,2\,SO_3) + 3\,HO] + 3\,(MgO,\,HO).$$

When, therefore, we consider that this mineral is itself magnesian, and is invariably associated either with magnesian rocks of an igneous character, or with distinctly metamorphic rocks, the change in which can scarcely have been effected without the agency of heat, such results are most valuable as bearing on the great question already discussed. This is even more the case when we consider the other result of Mr. Haughton's inquiry,—namely, that the red earthy base of the Cornish porphyry is identical in its chemical relations and constitution with the Galway serpentine, as it affords another illustration of the processes described by Ebelman, on the grand scale of the laboratory of nature.

Dr. Apjohn has contributed a very interesting notice of a new mineral compound brought under his notice by George M'Dowell, Esq., one of the Fellows of our College. It is represented to have been part of a central mass or nucleus, within a lode or bed of sulphur ore discovered in the Ballymurtagh district of the county of Wicklow; and on analysis proved to be a compound of simple or basic sulphurets of the three metals, iron, lead, and zinc, mixed up with a portion of the ordinary bisulphuret or iron pyrites of the lode, and represented by the formula—

$$FeS + PbS + 6\,ZnS.$$

The importance of sulphur as one of the great agents in producing some of our most valuable metallic ores necessarily strikes the philosophic geologist; and knowing, from its appearance amongst volcanic products, that it still exists in large quantities within the earth's crust, he cannot but watch with curiosity every phenomenon connected with it. At present, it is known that this elementary substance, when subjected to great heat, loses its fluidity, and assumes at a certain temperature a condition of viscous liquidity quite analogous to that of earthy matter when thus dissolved; and it may, therefore, be associated with lava or any other volcanic product when not in a condition to take fire and burn. The action, also, of a simple combining body on the metallic bases, associates it with chlorine, fluorine, borine, &c.; and it must therefore be received as one of the principal agents used by nature in modifying the earth's crust. This remarkable separation, therefore, of a distinct or definite mineral compound from the mass of the bisulphuret of iron is deserving of much reflection, and seems to imply some very peculiar

condition of the lode, which permitted a free exercise of chemical affinities and re-action. I think that much light would be thrown on the natural process by subjecting sulphurets to the action of intense heat in vessels from which air was excluded; and by whom could such experiments be better conducted than by my learned friend, Dr. Apjohn?

The papers of the present session have been principally of a physical character, describing remarkable phenomena, but not adding to our knowledge of the natural history of the epoch connected with them; and I much regret that our members, from that bias which they necessarily receive in their collegiate course, seem too much disposed to rest satisfied with such descriptions, which, however valuable, are only a part, and a small part, of geological science; however, I hope that the precepts and example of the able naturalist whom you have elected to occupy your Chair will bring back the inquiry (in part, at least) to the investigation of the zoology of our strata, and to the perfecting of our lists of organic remains, without which we must continue to reason on very imperfect data.

Mr. Haughton, in his paper on Rathlin Island, points out many interesting facts. He shows that the general dip of the chalk is from S. to N.; and as that of the chalk on the opposite side is from N. to S., we may assume that though the chalk of Antrim and Rathlin is overlaid by basalt, it has also been uplifted by it. This is consistent with the facts Mr. Haughton describes,—namely, that fragments of chalk are found in the dyke which runs up the valley west of the church, and that the basalt is intermixed with the chalk; and with a similar fact I described in my Geological Report, where a large block of basalt exists isolated in the chalk cliff. Mr. Haughton enumerates and describes several dykes which he considers to correspond with the dykes of Ballycastle, and not with those of Kenbane Head, as stated by Buckland and Conybeare. He describes a bed of lignite at Dunangael; and a bed of ironstone and several faults at Kebble Head, in a bed of ochre, which deserve especial consideration, as the general character of the strata differs so essentially from that of the clay and other strata in which faults so commonly occur. Perhaps the most interesting portion of this communication is that in which the author describes his experiments on some long basaltic pillars, and the determination by them that these pillars possessed distinct magnetic polarity, the upper end corresponding to the north pole of the magnet. The magnetic condition of rocks

has only recently engaged the attention of geologists, although it must now be evident that the stability of the universe depends on the balance between the paramagnetic and diamagnetic conditions of its constituent parts.

The joint paper of Dr. Sidney and Mr. Medlicott, on the Neighbourhood of the Town of Wexford, is in like manner unconnected with any zoological data. The limestone in the neighbourhood of the town is magnesian, and alternates with beds of shale; and it is worthy of remark that a large portion of the lower carboniferous limestones of the south of Ireland possess this magnesian character. Much of the limestone is highly crystalline, and full of small cavities, which sometimes contain very pure native sulphur. The limestone is conformable to the old red sandstone and conglomerate, which appear in the flanks of the hills south-west of the town, whilst the strata of the quartz rocks and clay-slate hills dip in a different direction to those of the limestone and old red, and at a higher angle. This is a point which should be carefully examined, in order to determine the correct geological formations of these several deposits.

In the last session of last year Mr. Haughton brought before the Society some examples of angular fragments of granite found in a bed of limestone opened in a quarry near Crumlin, county of Dublin. Such cases have been recorded before, but, as Mr. Haughton remarks, the fragments are here confined to a single bed, not occurring in those either above or below it, so that the force which removed and deposited them in the calcareous mud was only exerted during a limited portion of time. The nearest granite *in situ* is at Killikee, four miles distant; but to determine the exact nature of the phenomenon, it is necessary to know whether the line of dip or the line of strike is in relation to the granite. If the former, may not this be an ancient example of that description of mud slip which Mr. Mallet has explained? In a specimen obtained from a gravel bed, the enveloping limestone was a dolomite; but this condition was most probably due to a subsequent change similar to that which has been effected on the crystals of felspar of the granite. Mr. Haughton gives an analysis of the limestone boulder which contained the granite fragments, and reduces his analysis to the formula—

$$7\,(CaO,\,CO_2) + 6\,[(MgO,\,FeO),\,CO_2];$$

whilst he finds by an analysis of the dolomite from between Williamstown and the Rock station, that its composition is represented

by the same formula, though the composition is very different in the proportions of iron and magnesia;—in the first the proportions of carbonate of magnesia and carbonate of iron being as 35 to 1; and in the latter 26 to 12; and hence Mr. Haughton concludes, that the boulder did not come from that locality of the dolomite rock. But surely such reasoning cannot be admitted in geology; and as the boulder contained fossils, a better means of comparison might have been found in them. When we consider that the chemical action is here between the particles deposited as confused mud, we might well expect that these isomorphous compounds would vary at distances of even a few yards, or even in every specimen. The identity is, in fact, more nearly approximated to than might have been expected, as the proportions of argil are actually 14.64 to 15.66; and we must take care not to discredit this most valuable auxiliary to geology by applying it to the determination of geological questions beyond its reach.

Mr. Jukes's paper on the Geology of the South Staffordshire Coal-fields is one, also, which merely deals with the physical phenomena; but in this case, as the English formations have been so fully worked out, the deficiency is of less importance. Having shown the manner in which the carboniferous rocks dip under at both sides, the new red sandstone which lies between the Penine chain and the mountains of North Wales, and pointed attention to the insulated coal-fields of Leicestershire, Warwickshire, Staffordshire, and Shropshire,—in the latter of which the mountain limestone and millstone grit and Devonian shale are almost wanting, the coal measures resting on Silurian, or even more ancient strata;—he describes in detail the South Staffordshire or Dudley Field.

In this district the new red sandstone, carboniferous and Silurian strata, are all present. In the Silurian, soft shale predominates, having near the summit a twenty-five feet band of argillaceous nodular limestone, referred to the Aymestry limestone; at 1000 feet below, one or two bands, each 30 feet thick, referred to the Wenlock and Dudley limestones; and at 1500 feet lower, another band, 30 feet thick, referred to the Woolhope limestone, the top of the Caradoc sandstone appearing in one part of the district still lower. The coal formation is here made up entirely of *coal measures*, and is 1500 feet thick. It really contains about twelve distinct beds, which are, however, in some places brought together, so as to form, apparently, one bed 30 feet thick. Besides the stratified

rocks, there are several varieties of igneous or trap rocks, such as basalt, porphyritic, greenstone rocks, which are rarely wanting in disturbed districts; and this, though in part its tranquillity seems to have been unaffected, has not escaped disturbance, as is manifested by numerous faults. It is thus that in some places there is a perfect conformability between the new red and the coal measures, whilst in others the latter, and sometimes the Silurian strata below are seen tilted up, and cropping out at high angles; and Mr. Jukes points out the caution which such variations teach the miner to use in his estimates of the probability of finding coal under the new red sandstone, as it may happen that in some cases the Silurian strata alone may be found under it. Wherever, indeed, there are indications of internal disturbance, the geological problems of mining become complex, and require the greatest skill in their solution. Mr. Jukes records his discovery in 1850 of lias beds in Needwood Forest, and states his opinion that, as lias exists here and in Cheshire, it is probable that all the midland counties were once a great lias plain, and that the great boundary faults of the coal-fields are newer than even the lias. Such speculations are interesting, but it should be remembered that the lias was a marine deposit, and probably subject to many modifications and disturbances during its deposition.

The last paper I shall notice is a mineralogical one by Dr. Apjohn. It contains the analysis of a mineral purchased by Rev. Professor Jellett from a mineral dealer in Switzerland. Mr. Jellett suspected that it was new, and his suspicion was confirmed by Dr. Apjohn, in whose laboratory it was analyzed by one of his pupils, Mr. H. Wright. It forms a species of crust of a dull greenish-yellow colour, on the surface of an indurated talc schist, which contains brown granular garnets, and has white asbestos adhering to it. It scratches quartz, has a compact fracture, but is composed of numerous aggregated prisms, with rhombic bases, the angles of which are 60° and 120°. Its specific gravity is 3.741. The composition from two analyses is represented by this formula—

$$4\,Si\,O_3 + 2\,Fe_2\,O_3 + 5\,Ca\,O.$$

To reduce this to a rational formula, Dr. Apjohn first considers the peroxide of iron as performing the part of a base; but in this case it would be necessary to admit a form of silicate of lime, for which there is no analogy,—namely, two atoms of silicic acid, combined with five of lime; and he then views the peroxide as

an acid similar to the isomorphous substance, alumina, when the formula

$$2\,(CaO, 2\,SiO_3) + 3\,CaO, 2\,Fe_2O_3$$

is obtained, representing a compound consisting of a bisilicate of lime and a sub-sesquiferrate of lime, a compound which, Dr. Apjohn considers, may be readily admitted, as it has numerous analogies in its favour. This new mineral Dr. Apjohn names Jellettite, in honour of the distinguished mathematician who submitted it to him for examination. It is impossible not to perceive in this analysis matter for very interesting speculation. The very function which the peroxide of iron assumes in this compound is remarkable, and whilst it indicates how readily nature provides for all contingencies in the mineral kingdom, consequent on the confused mixture which takes place under the varied action of physical forces, it also shows that every combination is tied down by the most definite laws, and conforms to fixed types of mineral species. The character of this mineral as an incrustation is also curious; and as it occurs on a rock admitted by all geologists to be metamorphic, we may fairly assume that it also is a product of some specific action on the talcose rock, which has induced a new interchange of chemical affinities between some portion of its elements. It would be well in every such case to examine the rock immediately connected with the crust, as well as that at some distance from it, in order to have the limit of the change, if such has taken place.

Before turning to the communication of Mr. Mallet, I think it right to close this part of our subject, which is, in some degree, of a cosmical character, by a brief notice of the researches of Mr. Hennessy, as published in the Philosophical Transactions.* Mr. Hennessy's paper is entitled "Researches on Terrestrial Physics." He justly observes that little has been done in maturing or improving the hypothesis by which the figures of the heavenly bodies are theoretically explained since Clairaut published his unrivalled work on "The Theory of the Figure of the Earth." It is surprising that such should have been the case, and equally so that geology should have gained so little advantage from the theory of fluidity, a circumstance which Mr. Hennessy attributes to the limited view taken of the hy-

* Part II. for 1851.

pothesis,—namely, in considering that "the volume of the whole mass, and the density of the fluid, have not been changed by the solidification of a part of that fluid,"—a restriction which Mr. Hennessy does not consider entirely consistent with what is known of the solidification of fluids.

Having examined mathematically the general questions connected with the figure of the earth as an ellipsoid of revolution, Mr. Hennessy enters on the consideration of that change of general conditions which would result from the refrigeration or consolidation of a mass of heterogeneous substances reduced to or held in a fluid state by intense heat; and he assumes that whilst in such fusion chemical action would take place, leading to the formation of various compounds, which, according to their densities and compressibilities, would be arranged around the centre of gravity of the spheroid, until "at length the mass would consist of a series of spheroidal strata, each of uniform density throughout its own mass, and having that density expressible as a function of its axes." It does, indeed, appear to me that in the case of the earth, where the figure has been proved to be that of the ellipsoid of revolution, which corresponds to that of a fluid in motion round an axis, and where the variations of the force of gravity at the surface, except in cases of manifestly local disturbance, correspond also to such a theory, it is impossible to conceive any material deviation from this supposed regularity of internal arrangement; whilst the fact of such comparative regularity in the force of gravity proves the comparatively small thickness of the sedimentary and variable deposits of the external portion of the earth's crust. Mr. Hennessy then explains his views of the changes in density which must take place in the circulation of the strata of the fluid upwards and downwards, according to their loss of temperature above, or gain of temperature below. But here I must suggest caution, as it does not appear to me that we know sufficiently of the process of refrigeration, or of that of fusion in bodies which only attain a viscous fluidity, to assume that there is such an interchange of the strata of different temperatures as is observable in more perfect fluids. It is, indeed, more probable, that in the course of radiation of heat through a viscous mass, the nucleus has imparted its heat upwards, and has become solid as well as the crust; and if this be so, the time may come when the whole of this heat shall have been dissipated into space,

and the earth shall have become entirely a solid, at a very low temperature. May we not, indeed, imagine that the partial interruption of the passage of heat from the accumulation of badly conducting materials may have produced the glacial period of our geological system, and that the consequent accumulation of heat having at length melted these substances at their lower portions, the temperature has again risen, or perhaps is even now rising? Such, indeed, appears to me one not improbable cause of the variations of climate in past geological epochs, and one, too, which will explain the local variations in deposits of the same epoch. Mr. Hennessy has himself considered this case of a solid nucleus and crust with a liquid annulus; but it would be out of place to follow him here through the able analysis by which he searches for truth amidst the difficulties and obscurities of geological data; and I shall therefore now content myself with stating one remarkable result at which he has arrived, namely, that admitting the theory of a consolidated crust, the least possible thickness of that crust cannot be *less* than 18 miles, or *more* than about 600,—a result which appears to me very consistent with geological observations, and with a deduction I had arrived at from other considerations, as it appeared to me not necessary to assume a much greater depth than 100 miles for any igneous product with which we are acquainted. Mr. Hennessy has also shown that the original or fluid ellipticity of the earth was *less* than its present ellipticity; and I have little doubt, therefore, that he will hereafter be able even to reconcile the supposed form of Mars to the theory he has adopted, and that, too, without any hypothesis more arbitrary than the one which our learned Secretary has been obliged to assume in order to make it conform to the solid theory. He has also shown mathematically that there must be great friction at the junction of the crust and liquid nucleus; and further, that the evolution of gases from the strata diminishes as the thickness of the crust increases,—results which to me appear quite in conformity with observed facts, as the former evolution of chlorine, iodine, bromine, &c., must have been very great, if we judge of it from the amount of their products in combination in all parts of the earth.

In judging of the value of the researches and deductions of Mr. Hennessy, it is right to remember that Mr. Hopkins has come to very different conclusions in the second and third series of his Researches, published in previous volumes of the Philosophical Tran-

sactions, as to the least possible thickness of the crust of the earth, making it from thirty to forty times as great as that deduced by Mr. Hennessy; and as Mr. Hopkins's reasonings are founded on the necessity of reconciling this thickness to the various astronomical phenomena exhibited by the Earth in its rotation round its axis and revolution round the Sun, it is evident that the hypothetic assumptions of Mr. Hennessy must be carefully investigated, not merely as regards their probability *per se*, but also in respect to their harmony with great general results, before they can be received as a safe foundation for cosmical deductions.

Before leaving this higher branch of physical geology, I must regret that, not having seen in print the second part of Mr. Mallet's Report on Earthquakes, I cannot give that analysis of it which its great merits require. I may, however, observe, that I cannot see in the distribution of volcanic vents, as described by him, from the authority of various writers, any argument against the theory of elevation of mountain chains advocated by M. Elie De Beaumont. If placed on a map, and united by a line extending continuously one from another, they may, indeed, seem to indicate spiral or circular lines; but no one, I am sure, would for one moment consider that the axes of disturbance assumed such strange directions. The volcanic vents are, on the contrary, situated more probably on each side of an axis of disturbance, or in an area of disturbance, and may assist us in discovering that axis, though they do not actually mark it out. Two different kinds of talent are valuable in geological research,—that of patient elucidation of principles, so powerfully exercised by our esteemed member, and that of philosophical generalization, so eminently possessed by M. De Beaumont. Let both be applied, but let neither be undervalued nor neglected.

I must now turn to a subject painful to myself,—namely, the complaint which my friend Mr. Mallet has made, that from "an imperfect knowledge, apparently, of what the precise nature of his views were," I have unjustly denied to him the merit of originating a peculiar theory of the movement of detritic masses, and of their effects in grooving of rocks, &c. Assuredly I should feel ashamed were it possible for me to do injustice willingly to one so gifted and so honoured as my friend and fellow-labourer; but I must repeat, that my own conception of his original ideas on this subject, and, I may add, the conception of some of our most able members, was,

that Mr. Mallet's theory referred to the movement of semifluid masses of mud, gravel, &c., over the dry land, being, therefore, analogous to land slips; and I think the term "mud glaciers" could have no other reasonable application. In such a mind, however, as that of my friend, other ideas may doubtless have been floating, though not as yet fixed and reduced to order; but when we remember that he never reduced his ideas into such a shape as permitted their publication either in our own Journal or elsewhere, it would, I think, be a dangerous precedent to allow that the mere expression of these first thoughts was to act as a bar against the research of others, or to entitle their author to claim the discoveries even founded upon them. When I spoke in my paper on Bantry Bay of the extreme probability that the scratches on the rocks I there described had been made by pebbles moving in and with the great mass of boulder, I expressed only a fact, not a theory, though I certainly had my own speculative opinions on the subject. My arguments, therefore, on the point of originality were not personal as regards myself, but were just as regards the able writers who had discussed the subject of the movement of detritus, whether on the dry land or under water. Mr. Mallet has now explained (June 11, 1851) his theory, in the following manner. Assuming that the rocky skeleton of the earth has been gradually raised up with a coating upon it of detrital matter, he asserts that this matter will be gradually passed downwards from the higher lands by the formation of successive lines of temporary coast beaches within the limits of wave and tidal action, and "that successive slippages or slidings out, *en masse*, of loose materials, such as sand, mud, gravel, or earth, often bearing large boulders, will continually take place along every such coast, at the steep taluses formed along them by the tidal or wave action;" and the distribution of these materials "will again produce other similar slippages under water, and produce upon the subjacent rocks the phenomena of scratching, furrowing, rounding, &c.," and "simulate all the principal traces of glacial action, for which, and for evidence of a supposed arctic or glacial period, I consider they have been frequently mistaken." It is to such movements of detritus that Mr. Mallet now says, "he first gave the name of mud glaciers," —that is to say, "to masses of slipping materials whether under water or above water." Further, Mr. Mallet states, as a corollary to his first proposition—"that around all the existing coasts the for-

mation of such masses of loose materials, and their continuous or intermittent slippages, are in daily progress, and that the grooving and furrowing of rocks beneath is now taking place thereby, and the transport within such masses of large boulders detached from sea-cliffs, which are thus gradually transferred into deep water, and often to vast distances over the floor of the ocean, whence they would emerge, and be left isolated, if at a future time such floor should become dry land." I need not follow Mr. Mallet further than to state that he represents denudation not as the result of any debacle such as a sweeping away, but as a cutting away by current action, and the movement of the mass "bodily by a *vis a tergo*,—namely, the weight of the mass itself of loose materials acting as a semi-fluid or plastic body, bearing and carrying along with it included boulders, stones, &c."

Such, then, is the theory of Mr. Mallet, as now proposed. The facts are undoubted, and must have been observed by every one who ever looked upon a sea-coast on which the sea was encroaching; but are they adequate as a cause to account for the grooving of rocks and the movement of boulders? Has any one ever observed scratches or grooves produced by land slips, or by mud debacles on land? and is it probable, therefore, that any semifluid mass slipping down under water could produce such effects? Is the removal of matter by the action of currents, so often observed and recorded in our tidal rivers, conducted in this way, and is it not rather by the falling in of the top so as to produce a bank towards the wave? Much use may, doubtless, be made by the geologist of such movements, and, doubtless, both land and coast slips, combined with shifts of banks, have occurred at all geological epochs; but I think few will recognise in this agency a cause which will account for the removal of massive boulders and the distribution of detritus over lines 200 or 300 miles long, or even for the formation of the grooves and scratches of rocks which often occur in positions which cannot be reconciled to such a theory. If Mr. Mallet had gone one step further, he would have included the speculation present in my mind, and it is even probable that he did intend to do so. That view is this: that such masses of matter could only produce such results by their motion when consolidated by great pressure, and hence, that when by internal disturbance undulations of the deep sea-bottom were formed, the consolidated mass might slip along the now inclined sur-

face, and, holding firm the imbedded pebbles, groove the subjacent rocks. Such masses, also, might be firm enough to hold boulders on their surface, which assuredly they never could do when semifluid along a sea-coast. Even this modification or extension of Mr. Mallet's is only sufficient to account for some peculiar cases of grooving, and not for the more general phenomenon. Mr. Mallet's reputation is too high, from researches of a truly original character, to require any support from so uncertain a theory.

It does not, indeed, appear possible to limit the number of formative and modifying causes which have acted from time to time in producing the results we now observe in the present condition of the surface of our planet. Something new may be discovered from the observation of almost every local phenomenon. M. Le Colonel Joaquin Acosta has in this manner studied the curious mud volcanoes of South America, and communicated very interesting information respecting them.* It appears from his statement that the gas issuing from these volcanoes is not, as Humboldt supposed, nitrogen, but carburetted hydrogen, having a bituminous odour, which it derives from the petroleum which oozes out at the surface of the mud. Colonel Acosta considers the mud volcanoes of Turbaco as connected with the great phenomenon of mud volcanic vents so fully developed on the coast of the province of Carthagena, and having as a focus the volcano of Galera Zamba. Colonel Acosta had previously described the destruction of the Trachytes of Ruiz, and the mud inundations of the central Cordillera, and he now states, that on descending the Madalena he satisfied himself that the mud of various great inundations of this volcanic character had been consolidated at successive epochs along the course of that river. It is in this manner that the ordinary superficial gravel or drift has been covered over by a trachytic conglomerate. M. Acosta promises a chart of the Madalena, in which these curious deposits, which diminish in extent as the river approaches the sea, will be exhibited and explained; and I cannot but anticipate much instruction from it, as there can be little doubt that similar eruptions and deposits have occurred at many past geological epochs.

In turning now to the organic branch of geology, I feel that I should not be justified in dwelling long upon it, as the labours of

* Annales de Chemie, January, 1852.

our Society have not been directed towards its extension or elucidation during the present session. It is impossible to repeat too often my expression of regret, that a branch of inquiry, which is so essential to the determination of individuality in formations, should have been thus neglected, or my hope that the charms of cosmical speculations, even though they may be founded on sound analytical deductions, will not much longer seduce our members from the investigation of the laws of organic creation.

In my Address of last year I drew your attention to the monograph of Permian Fossils by Mr. King. This geological system or formation deserves some further remarks, as it affords another example of the successful generalization of Sir R. I. Murchison, only second in its importance to his still more remarkable Silurian system. It is well, however, that we should first clearly understand the characteristics which ought to be required in every geological system, and these are, that both the physical and organic conditions should be represented. So long as the apparently insignificant deposits of the German Zechstein and English Magnesian limestone could alone be quoted as evidences of a distinct epoch in the history of creation, it would have been rash to attempt the establishment of a system; but when Sir R. Murchison discovered in Russia examples of the varying results of the several forms of action which must ever be simultaneously at work on the earth's surface, and lead to corresponding deposits, it was manifestly safe to attempt a great generalization, and to include these partial deposits in one great system. Sir R. Murchison did this, as he had previously done in respect to the Silurians, and now the Permian system has been adopted by all geologists. Dr. Moritz von Grüneweldt* has, in papers read before the Geological Society of Berlin, contributed some very interesting additions to our knowledge of this formation. Von Dechen had previously stated that the Zechstein continued into Silesia on the north slope of the Riesengebirge, and Dr. Moritz has now described the fossils collected there by himself and Professor Beyrich. He justly observes that in this formation, as in every other formation, local variations in the fauna must be expected, for were it not so, the conditions of the ancient world must have differed entirely from those of the present; or, in other words, nature

* Journal of the Berlin Geological Society, May, June, July, 1851.

must have acted then according to different laws than those by which she is now regulated,—an hypothesis which finds no support from the observation of facts. Making allowance, then, for this natural difference, the fauna of the world at this remote epoch exhibits a very striking similarity at the three points of observation, Russia, Silesia, and England, which appear to have fallen either on the margin of the Permian sea, or on some shoal adjacent to its shore. The numbers examined and identified by Dr. Moritz were—

Cephalopoda.—One species, common to Russia, Silesia, and England.

Gasteropoda.—Two species, common to Silesia and England.

Conchifera.—Six species, common to Silesia and England, of which three species are common also to Russia.

Brachiopoda.—Productus horridus, England, Silesia, and Poland; Terebratula elongata, common to Russia, Silesia, and England.

Crinoids.—Cyathocrinus ramosus, common to England and Germany.

Bryozoa.—Two species, common to England and Germany.

Polyps.—One species, Germany.

It is manifest that so far as these limited data of comparison permit us to judge, the analogy of the fauna of Permian Germany was nearer to the English than to the Russian type of the epoch, though at the same time there is ample evidence of its close relation to that of Russia. I may here, perhaps, with advantage make some few remarks on the use of these geographical terms, Permian, Silurian, &c., for the designation of geological formations. It appears, indeed, to be a very wise arrangement, as it points at once to a typical district in which such formation has been found fully developed, and, in consequence, has been there studied with advantage. The practice is every day gaining ground, and M. Alcide d'Orbigny has in consequence given such geographical names to all the subdivisions of both the oolitic and the cretaceous systems. To make the method, however, really valuable, it must be remembered that the importance of the district itself, in any other than a geological sense, has nothing to do with the question, and, consequently, that the system of Siluria may be reasonably extended over Cambria or Wales, and that of Permia over Germany and England. There is, indeed, no logical inconsistency in this, for whatever may be the

present relative geographical importance of districts, by the geologist their value must be determined by the comparative development of their organic inhabitants at that ancient epoch which may be the subject of study. The propriety, therefore, of extending the local names of Bath, Kimmeridge, &c., where some peculiar fauna has been studied with advantage (though they may not be so harmonious as those of Siluria and Permia), over continental districts of probably greater geographical extent and importance, will not, I think, be disputed by any modern geologists.

The "Traitè Elementaire de Conchyliologie" of M. Deshayes, which promised to be so valuable an auxiliary, both to the pure conchologist and to the geologist, has been again resumed, after a long suspension, in consequence of the author's absence in Algeria. The last part begins with the important family "Cardiaceæ," which M. Deshayes still restricts to the genera Cypricardia, Isocardia, and Cardium, as he had done in "L'Encyclopedie Methodique." After pointing out the erroneous extension of this family by some writers, and its equally erroneous restriction by others, he quotes the authority, in terms of justly merited praise, of Professor Edward Forbes and Mr. Hanley:—"In their excellent work," he says, "on the Mollusca of Great Britain, they have been led by similar facts to the same conclusions; and there is every reason to believe that their opinion will be confirmed in proportion as observations shall be multiplied." In approaching a family so familiar to us in our existing fauna, we appear to be entering on known ground; and every species we meet becomes interesting, as it admits of a direct comparison. Commencing with the genus Cypricardia, M. Deshayes points out that though the hinge may in living species be always trusted as a sufficient character, the modifications from age being slight, it cannot be trusted in the examination of fossil species, of which many, having no teeth, exhibit all the internal peculiarities which mark a similarity of structure in the more important organic elements. Although, however, this view of the superior importance of the more purely zoological characters is quite in accordance with the philosophic systems of modern zoologists, it would be unwise to overlook so great a variation in the structure of the hinge of the shell, and not to draw from it, as a conclusion, that the change from a condition in which there were no teeth to one in which the teeth are strong and highly developed, at least points out some pe-

culiar adaptation to circumstances which have undergone a similar variation. In the genus Cypricardia M. Deshayes places the greater number of the fossil species of Sanguinolaria, and powerfully contends against the opinions of M. D'Orbigny, who has allocated many of them to his genus Lyonsia. The species he thus distributes:—To the Lower Silurian he gives seven, some of which have been found in America, some in Russia, and one only in England; and to the Upper Silurian twelve species, six of which have been described by Mr. Hall in his "Palæontology of the State of New York;" five have been found in England, including the *Cypricardia impressa* of Phillips, which extends into the Devonian; and one, the *C. inflata* of Eichwald, which was first discovered in Russia, but has since been found in Belgium and England in the same zoological position. The Devonian is very rich in species, twenty-two having been described, in which number nine Sanguinolariæ of Goldfuss are included. They are spread over America, Russia, Germany, and England; some species, such as *Cypricardia cymbæformis*, being common to England and Russia, whilst, on the contrary, not one appears *to have passed the ocean* from America to Europe, as has been observed in species of other genera. The *Cypricardia striata* (*Sanguinolaria striata*, Munster) passes from the Devonian to the Carboniferous, having been found simultaneously in the Eifel, and at Visé, in Belgium. Thirteen species have been recorded from the Carboniferous, the greater number from Belgium. Of these, four species are peculiar to England and Ireland, and three deserve especial notice, as they extend from Belgium to England, namely, *C. parallela*, *C. squamifera*, and *C. rhombea*, the latter being also common to Russia. M. Deshayes also suggests that the shells of Australia, collected by Mitchell and Strzelecki, and described by Sowerby under the generic names Megadesmus, Pachydomus, Orthonota, Euridesmus, and Allorisma, should be placed in this genus, the thickness of the ligament not being a sufficient character to establish generic distinction. At this geological stage the genus appears to have been curtailed in its development, as the Permian has produced only one species, the *Cypricardia bicarinata* of Keyserling; and the *Muschelkalk* (of the Trias), usually so rich in fossils, also only one, according to Deshayes, the *C. gregaria*, although M. D'Orbigny admits four species.

In the Oolitic formation—a series of formations—the number

of species rises to nineteen, or rather to twenty-two, including the three new species which M. Deshayes now describes for the first time. Six species are peculiar to the Lias of France and Germany, and one species, the *C. terea*, appears confined to the Lias of Lorraine; seven species are found in the lower Oolite,—namely, two in England, one in Germany, and four in France; and of the latter, the *C. cordiformis* of Deshayes has so wide an extension as to characterize the deposit, having been collected in Normandy and Lorraine. M. D'Orbigny has discovered one species in the "Bathonian section" (the Bath Oolite); two other species extend from the middle Oolite to the lower portion of the "Oxfordian section;" three species being cited in this latter section; and M. Deshayes points attention to Vieux Saint Remi as a locality where its fossils can be studied to the best advantage. Two species are known from the Coral Rag, having been described by M. Bruguiere, in his work on the Geology of the Department of the Meuse.

The Chalk is very poor in species, having yielded not more than one or two species, and Professor Edward Forbes has described one, *C. undulata*, from the Greensand. The Tertiary strata are also very poor, four species having occurred in the lower Tertiaries, one of which, the *C. pectenifera*, has been found both at Barton and in Belgium; and two others are peculiar to the Paris Basin; two species in the Miocene of Europe, as described by M. Grateloup; and one in the Miocene of North America, the *C. arata* of Mr. Conrad; and three species in the upper Tertiaries, each of which has its living representative,—namely, *Cypricardia coralliophaga* (Lamk.); fossil in Sicily, Italy, and the neighbourhood of Bordeaux and Dax; living in the Mediterranean, *C. Mediterranea* (Desh.), allied to the preceding, but always more wide and short; it is lithophagous; fossil, it occurs in Italy and at Navarino, where it was discovered by M. Jeangerard; *Cypricardia oblonga, Chama oblonga* (Linn.); fossil in the recent Tertiaries of Egypt; living in the Red Sea and Indian Ocean.

It is thus that this genus was at a high state of development at the very earliest epochs of the earth's organic history; became then suddenly restricted to a very small number of species, but continued to exist up to our present creation, in which, however, it is represented by only seventeen species.

In contemplating these very remarkable variations we must not

forget the remark I have made at the outset,—that the early type of the genus was found in shells which had toothless hinges, and the recent type in those which have fully developed teeth; so that it would appear that there really is a very strongly marked line of demarcation between the ancient fossil and the recent shells; the genus having been renewed on a new type of structure.

The genus Isocardia first appears in the Devonian strata, from which eight species have been obtained; one, *Isocardia tanais*, having been discovered in Russia by M. de Verneuil, and the others in Germany and England. The Carboniferous strata have supplied three species: two from Belgium, and one, *I. oblonga* of Sowerby, common to Ireland, England, and Belgium, and therefore characteristic of the formation.

The *Muschelkalk* (Trias), including the formerly disputed beds of Saint Cassian, in the Tyrol, has yielded nine species, all from that once celebrated locality.

The genus now diminishes for a time in importance, four species alone, and all of them not restricted to this particular section, having been obtained from the Lias; nine from the lower Oolite, some of them being of doubtful relation to the genus; four species from the great Oolite, one of which, the *I. rostrata* of Sowerby (not Goldfuss), is common to Germany and England; eleven species from the Oxfordian beds of various parts of Europe, of which *I. tenera* of Sowerby is common to France, England, and Switzerland. One species only has been satisfactorily determined from the Coral Rag, and one from the Kimmeridge section. The Chalk has yielded nineteen species, and the Greensand four; and the *Isocardia cretacea* of Goldfuss deserves especial notice, having been found in Germany, England, and recently by Mr. Sharpe in Portugal. The Tertiary strata are less rich in species, as they have only yielded fourteen species, including the still living *I. cor*. The *I. sulcata* of Sowerby is peculiar to the London clay, and the *I. Parisiensis* to the *calcaire grossiere* of the Paris Basin; the *I. crassa* is common to the Crag of England and Belgium, and the *I. rustica* of Conrad is the American representative of *I. cor*. Of recent species, the *I. cor*. alone is found fossil; it first appears in the Crag of England and Belgium, and in the more recent Tertiaries of Italy, Sicily, the Morea, Cephalonia, Algeria, and Perpignan.

The genus Cardium is one of the most important and widely

diffused in nature, and is retained by M. Deshayes as it was left by Linnæus, Bruguiere, and Lamarck; the subsequent dismemberment into the genera Cardissa, Pleurorynchus, &c., being in his opinion unjustified by true zoological characters. Of this genus, 150 living species have been described, and about 500 fossil species have received distinctive names, though, without doubt, a very large number of them are only multiplications of the same species under the same name, an evil far too common in palæontological works. The genus commences in the Silurian with twelve diminutive species, six of which (referred by Mr. Hall to the genera Edmondia and Cardiomorpha), are from the Trenton limestone of North America, and six from the Silurian strata of England, Sweden, and Germany. By a singular phenomenon, not often repeated, the genus suddenly expands in the Devonian into seventy-nine species, or, including two or three species common to the Silurian and Devonian, into eighty-one or eighty-two. Many of these species appear to be very local, and though forty-eight species have been discovered in the Devonian district, which extends into the Rhenish provinces, into Bavaria, Westphalia, and Saxony, few of them have any lateral extension. Of exceptions, M. Deshayes cites *C. semistriatum* (Goldfuss) common to Bavaria and Northern Russia, and *C. glabrum*, extending from Bavaria to Bohemia, whilst *C. clathratum* is as yet peculiar to the Asturias.

Four Devonian species are repeated in the Carboniferous strata, and twenty other species, bring the total number to twenty-four. One of the most remarkable species is the *Cardium Hibernicum* of Sowerby, which exhibits so abnormal an external form as to have led to the formation of the genus Conocardium by Munster, the genus Pleurorynchus by Phillips; and to this peculiar form belong no less than ten species, including the *Cardium Uralicum* of De Verneuil, which is peculiar to Russia, and the Irish species, *C. inflatum* and *C. eduliforme*, described by M'Coy. After the Carboniferous epoch, this genus, which had yielded one hundred and eleven species, almost disappears, not one having as yet been recorded in the Zechstein, and only one in the Trias (Muschelkalk). In the Oolitic series of formations, the genus becomes again developed; in the Lias, nine species have been discovered, one of which, the *Cardium multicostatum* of Phillips, requires a new name, as Brocchi had previously appropriated that name to a Tertiary species,

and that of *sub-multicostatum*, given by D'Orbigny, appears to M. Deshayes objectionable. In the lower Oolite five species have been found, one of which, *C. cognatum* (Phillips), is common to England and Germany; and another, the *C. citrinoideum* (Phill.), after appearing in England in one bed, re-appears in France in another more elevated in the series. From the great Oolite twelve species have been obtained, and from the Oxfordian section six; of which the *C. concinnum* of De Buch has been found in Russia, England, Scotland, and France. The Coral Rag has yielded nine species, including two, *C. cyreniforme* of Buvignier, and *C. intextum* of Munster, which came up to it from the subjacent section. The upper Oolite has produced only one; and the Kimmeridge of the Meuse several. Here again, another series of more than forty species disappears, but in the Cretaceous formation the genus becomes again fully developed; the lower Greensand yielding twelve species; the Gault four, including one which comes up from the lower Greensand; the upper Greensand twelve; and the Chalk more than thirty.

From the lower Tertiaries thirty-two species of Cardium have been described; probably a far larger number lived in the Miocene epoch, though as yet the confusion in its fauna renders it difficult to determine them with precision; and from the upper Tertiaries have proceeded thirty species. It is impossible in this abstract to give any idea of the critical acumen with which this able naturalist examines and corrects the labours of preceding and contemporary writers, and of the vast number of corrections in nomenclature which he proposes, on apparently sound data. In one great point he is opposed to M. D'Orbigny, as he maintains the passage of some species from one member or section of a formation, and therefore controverts the theory of D'Orbigny as advanced in his Palæontologie of the French Cretaceous Formations,—that each section is distinguished by its own peculiar fauna. However disposed most geologists were some years ago to accede to D'Orbigny's theory, which is indeed only a revival of that of earlier days, the tendency at present is certainly towards the adoption of the modified theory of Deshayes. I have dwelt thus long on this most important portion of M. Deshayes, both because I feel rejoiced at seeing so able a zoologist again engaged upon the difficult task of comparative palæontology, and because the consideration of this family of shells, the Cardiaceæ, is full of interest. From their habits they are principally shore

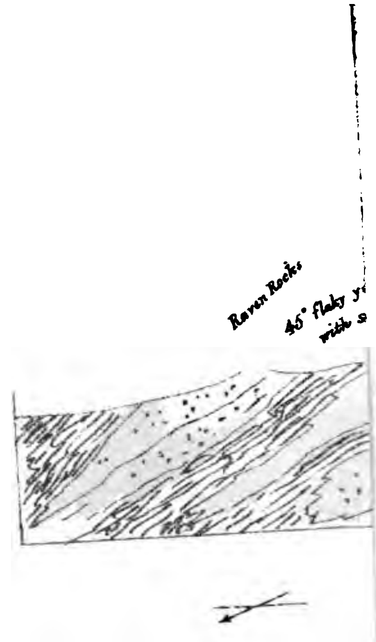
shells, and as some of them are even fond of brackish, or almost fresh water, they bring us as it were up to the dry land. The remarkable fact, also, that the shells of the earlier species were not provided with teeth seems to connect them more closely with fresh-water shells, and to open out to us a view of a former condition of the earth, in which fresh-water seas were at least not wanting. The present course of geological investigation is certainly directed to the discovery of more evidences of land and fresh-water, than were formerly thought probable, and it is therefore interesting to find even these slight indications from analogy of such conditions. I will add here a reference to what has always appeared to me a proof of the existence of dry land, were it now necessary to maintain its existence by argument, at all geological epochs; and that is, the formation of beds of limestone. So far as existing analogies assist us, the course of nature has been to act by atmospheric agencies on the exposed rocks, to decompose them, and then to transfer in solution the carbonate of lime from the land to the sea. Such is the course of nature, as she can be studied in the existing creation, and I cannot doubt that in every past age of the world the brook and river were, as now, the agents by which mineral matter was conveyed from the dry land to the sea; and I am forced therefore to look upon our present ocean as the result of long-continued actions of this kind. I have felt that I could not, under the circumstances I have previously detailed, go further into the work of M. Deshayes, and follow him into the families, Camacea, Cardita, &c.; nor can I do more than briefly allude to the last published portion of the great work of M. D'Orbigny, which contains an investigation of the Escharidæ of the Chalk, and also of the species of the family Flustrellaridæ and the importance of which may be judged by the fact, that M. D'Orbigny describes no less than fifty-four species of the one genus, Biflustra, from the several stages of the Chalk of France; and he thus observes:—"I have united the region of the Loire to the Anglo-Parisian chalk basin, and when thus united they have, in common with the Pyrenean basin, eleven species—a number so great as to prove the contemporaneity of the two basins (the Pyrenean and the Anglo-Parisian)." If viewed geographically, and without reference to the repetition of the species, the following is the development of this genus in the Senonian stage of D'Orbigny:—Neighbourhood of Paris, six species; the channel district, nine species; the region of the Loire,

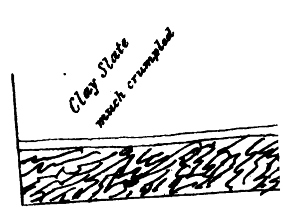
nineteen species; and in the Pyrenean basin of Saintonge, twenty-three species;—or, uniting them into basins, the numbers are—for the Anglo-Parisian basin, thirty-four; and for the Pyrenean basin, twenty-three species,—a curious illustration of the contemporaneity of these two ancient seas.

In the 184th livraison of his work M. D'Orbigny commences his description of the Bryozöaria; and though we cannot follow him in this part of his subject, the value of his researches may be judged from his statement, that the Chalk formation of France alone has yielded more than 870 species. Nor will I attempt to analyze the recent parts of his "Paleontologie" of the Oolitic system of France, which are devoted to the description of numerous species of Gasteropoda, as it is sufficient for my purpose to state, that whether our consideration be given to animals of a comparatively high organization, or to those of the lower standard of Bryozoaria, the peculiarities and the individuality of each ancient stage of the world's history is fully maintained; not, it is true, with that rigidity of outline which does not admit the passage from one to another stage of even a single species, but with all the essential features so strongly marked as not to admit of hesitation in determining the identity of each.

I shall, therefore, now close my remarks by dwelling very briefly on some remarkable facts, of a still more striking character, which the researches of the past year have brought before the public. For a long time, as you are aware, it was supposed that reptiles first appeared on the earth at the Triasic epoch, the footprints discovered on beds of the new red sandstone having been referred by Professor Owen to his genus Labyrinthodon; but subsequently the class has been carried back to the Carboniferous in the genera Archegosaurus and Apateon; and as the former exhibits, as it were, two types of structure, the Saurian and Batrachian, blended together, we may assume, that at this stage commenced that great development of the class of reptiles which seems to indicate that for a long series of creations, reptiles performed the functions which are now, in a more balanced system, allocated to animals of several distinct classes. In the old red sandstone of Elgin, in Scotland, a reptile has still more recently been discovered, the *Telerpeton Elginense* of Dr. Mantell, in which there are also indications of the simultaneous development of these two types, the Saurian and Batrachian; and Sir Charles Lyell has reminded geologists that the footprints of a fresh-water

tortoise had been previously discovered by Mr. Logan and the Canadian geologists in the Silurian strata of Canada, thus carrying the class back to the very dawn of known animal life. But it is still more curious to find the higher class of Mammals also retreating in their origin to more remote epochs. In 1847, M. Jäger published a most valuable paper in the Transactions of the Society of Naturalists of Bonn, in which he describes numerous Mammals from the Tertiary strata, and two from the Breccia which lies between the Lias and the Keuper. One of these, the *Microlestes antiquus* of Plionenger, seems to belong to the Marsupial type; whilst it is yet doubtful whether the other, *Sargodon tomiens*, is really a Mammal, as M. Jäger expresses a doubt whether it may not belong to the genus Capitodus of Munster, described as a fish in his description of the fossils of the Vienna Basin. This early appearance of the Marsupial type, now almost isolated in Australia, and its recurrence at the Oolitic epoch, are facts of the highest philosophic interest, more especially when it is remembered that there is a similar resemblance in the ancient Flora to that of Australia. It is evident, indeed, from the study of successive creations, that certain forms were more peculiarly developed at certain definite epochs; for example, the Trilobites of Crustacea, and the Nautilidæ, of Cephalopoda, at the Silurian; the class of Reptilia at the Oolitic; the family of Ammonitidæ, of the Cephalopoda at the Cretaceous; the Pachydermata, of Mammals in the early Tertiaries; whilst in the present creation all these types seem properly restricted, and the whole blended into a balanced system, as if prepared for the final and greatest terrestrial work of creative power and wisdom,—Man. It is thus, therefore, that we are justified in saying, that whilst one geological age may be called the age of fishes, another that of reptiles, this is peculiarly the age of Man. In studying it we are applying powers which were denied to other animals, and, although humbly using an intelligence which partakes of the essence of Divinity, we may freely, but reverentially, unfold the mysteries of creation, as they are exhibited in the book of eternal nature, and learn, at least, from the contemplation, that great as Man confessedly is when compared with the irrational creatures associated with him in this world, he is as a mere nothing when compared with the Divine Creator of all things.


Raven Rocks
45° flaky


Clay Slate
much crumpled

November 10, 1852.—"Limestone Boulders of Corkaguiny, County of Kerry."

THE following letter to the Secretary, from the Rev. A. B. ROWAN, was read:—

"BELMONT, TRALEE, *October* 22, 1852.

"SIR,—Some months since, walking with a friend on the borders of a small rivulet (occasionally a torrent when swollen by rains), in a mountain glen in the barony of Corkaguiny, county of Kerry, I saw, lying in the bed of the stream, a remarkable mass of rock, quite different in shape and colour from the boulders of conglomerate and sandstone around it. I immediately said, 'That is limestone.' My friend, one of the best practical farmers in the district, and fully alive to the value of limestone manure, smiled, and said, 'A block of limestone of that size would be a valuable article here.' We descended into the stream, examined, broke off a fragment, and ascertained beyond doubt, that the rock, measuring nine feet by four superficially, and containing many tons of solid content, was crystalline limestone of a pure and compact quality.

"In order to show the peculiarity of the facts I am about to notice, I must describe our position by referring to the 'Outline of the Geology of Kerry,' furnished by Mr. Hamilton, in volume i. pp. 276–285, of the Journal of the Geological Society. We were standing in the valley which he describes as running from Ballygobbin (Kilgobbin) to Castlemain, under the west end of the great sandstone range of Cahirconree, and facing that mountain as it terminates abruptly in a steep face of about 2700 feet elevation. The water-course in which this block of limestone lay flows eastward from that great Corkaguiny range which, as Mr. Hamilton states, is 'composed chiefly of a "coarse siliceous conglomerate,"' but through which, seams of clay and red roofing-slate are occasionally intermixed. *There is not the least vestige of limestone anywhere to the westward* in the whole peninsula of Corkaguiny; and the valley in which we stood is at an elevation of about 600 feet from the sea-beach at Kilgobbin, where, at about two miles distant to the northward, the limestone of the Tralee basin, which dips at the point of Annagh, about six miles to the eastward, again crops up, and shows itself below high-water mark on the shore.

"After this mass was found, my workmen frequently pressed me to consign it to 'the kiln,' and 'murmured at the waste' of

leaving it in its rocky bed, while the material for lime-burning was drawn from a considerable distance. But as I regard the geological curiosity of its position far beyond any value it could obtain as a manure, I have given strict directions that it shall not be disturbed, in the hope that some geologist of larger knowledge than myself may think it worth examination, with a view to working out the problem, '*How came it here.*'

"A few days since, having a leisure hour to spend among the mountains, it occurred to me, that possibly more of these limestone blocks might be found in the same mountain stream; and, hammer in hand, I set out to explore, making my way upwards over the masses of conglomerate with which the bed of the stream is filled. I was not disappointed. I presently found another limestone boulder, and another, and then another; they were generally of small size; though some, imbedded in the gravel, may be of greater dimensions than I have yet ascertained; and I found only one approaching the dimensions of the first discovered mass. At length, having reckoned about a dozen of these erratic blocks, I came to a scaur or bank of earth overhanging the ravine, about ten or twelve feet, which I conjecture to be the nidus from which, *at their last remove*, these blocks have at intervals fallen into the stream below, and been carried down to different distances by the force of the torrent. A number of round blocks of sandstone and conglomerate protruded from the face of this bank, and among them one or two of limestone, which I have not yet disturbed; I examined the stream some way further up, but discovered no limestone beyond this point. All the limestones I found showed fossils, and, with the exception of the first, presented the usual appearance of water-borne stones, round and smooth; the largest block is of a different shape from the rest, being a parallelogram, with rough edges, much honey-combed on the surface, and having one or two deeper cavities such as I have seen elsewhere in limestone formations caused by a sand or other hard stone, lying on the surface, and under the action of the waves working for itself a bed in the depth of the stone, more or less deep as the action of the water is more or less violent.

"The two larger blocks are marked by distinct, well-defined bands of *chert* standing out from the surface of the stone, as resisting the action of the elements, under which the softer limestone yields and wears. I present these facts for the consideration of

scientific geologists, in order that they may speculate, and, if possible, decide, by what agency these masses have been transported from their native bed *upwards* into a mountain glen lying two miles distant *from*, and *at least six hundred feet above*, the nearest limestone formation in the district. No 'glacier theory' can help us in this difficulty, for I believe all transport of 'moraines' and other foreign substances by glaciers is from *above downwards*—and not, as in the present instance, in a direction contrary to that of gravitation.

"Perhaps it may help investigation, if I observe, that I think I have observed, on the face of the opposite mountain of Cahirconree, three distinct horizontal bands at different elevations, for the origin of which I can offer no reasonable conjecture, except that they *may* belong to the phenomena of ancient 'sea-beaches,' of which so many traces are now reported from different parts of the world; the mountain side is too steep to show any signs of 'detritus' or other remains of a sea-beach; but to the eye observing them from below, they present all the appearance of tidal lines scored on the side of the rock at different elevations. I cannot pretend to do more than present these facts for investigation, and to offer any geologist who may think them worth looking after any aid in my power in his further researches.

"I am your obedient servant,
"A. B. Rowan."

"Account of the Gangue of Conlig Lead Mine, County of Down;" by the Rev. Samuel Haughton, Professor of Geology in Trinity College, Dublin.

During a recent visit to Conlig lead mine Mr. Haughton's attention was attracted by the peculiar appearance of the gangue of the lode, particularly by the asbestiform streaked appearance of the dark green crystals forming the walls of the lode. This mine has been very rich in galena for some time past, and was formerly very productive, but from about the 60 fath. level to the 90 fath. was comparatively unproductive. The gangue of the lode presents the same appearance from the surface to 120 fath. deep; it crumbles when exposed to the action of the air; is full of joint surfaces, which are coated with a mineral of the same chemical composition as the gangue itself, crystallized in an asbestiform manner, as shown by the accompanying specimens. The specific gravity of the gangue is 2.721; it fluxes

readily before the blow-pipe into a black slag, and behaves in general as an ordinary trap rock.

Mr. Haughton gave the two following analyses, made by himself and the Rev. Joseph A. Galbraith, from different specimens of the gangue. In both analyses the mineral was fluxed with carbonate of soda and potash, as it was found not to be completely decomposed by strong muriatic acid:

No. I.

	Grains.	Per Cent.	Atoms.	
Weight	= 25.86	100		
$Si\,O_3$	= 11.35	43.88	0.969	1.256
$Al_2\,O_3$	= 3.82	14.77	0.287	
Fe O	= . . .	12.98	0.360	1.255
$(Fe_2\,O_3)$	= 3.73			
Ca O	= 2.64	10.19	0.364	
Mg O	= 2.81	10.88	0.531	
H O	= . . .	8.00	0.888	
		100.70		

This analysis may be well represented by the rational formula:

$$3\,[(Fe\,O,\,Ca\,O,\,Mg\,O),\,(Si\,O_3,\,Al_2\,O_3)] + 2\,H\,O$$

No. II.

	Grains.	Per Cent.	Atoms.	
Weight	30.00	100		
$Si\,O_3$	13.13	43.76	0.966	1.194
$Al_2\,O_3$	3.52	11.73	0.228	
Fe O	. . .	14.34	0.398	1.258
$(Fe_2\,O_3)$	4.83			
Ca O	2.716	9.05	0.323	
Mg O	3.225	10.75	0.537	
H O	2.40	8.00	0.888	
	29.82	97.63		

This gives the same rational formula as before. The mineral has, therefore, the composition of an hydrated aluminous hornblende.

Besides the constituents given above, a small quantity of chrome iron was found present in both specimens.

The Conlig lead mine is the only instance which has come under Mr. Haughton's observation of a pure hornblende constituting the gangue of a lead mine.

December 8, 1852.—"Notice respecting a Variety of Magnetic Iron Ore from Rynvile, near the Killeries, County of Galway;" by JAMES APJOHN, M. D., Professor of Chemistry and Mineralogy, Trinity College, Dublin.

THIS mineral, a specimen of which I obtained from Ethelstan Blake, Esq., of Rynvile, is massive, its recent fracture being of a dark colour, and exhibiting frequently the facets of minute octohedral crystals. It abounds in joints, according to which it generally splits when struck with a hammer, and whose surfaces are usually reddish brown from the presence of the hydrated peroxide of iron. Numerous thin laminæ of a schistose serpentine intersect this mineral, and it has usually attached to it small particles of iron pyrites. Its specific gravity is 3.3953, and it acts powerfully on the magnet.

Submitted to analysis it gave the following results:

Silex,	46.89
Alumina,	2.71
Peroxide of Iron,	39.04
Magnesia,	6.00
Water,	8.70
	103.34

With a view to this analysis the ore was first fluxed, for without this preliminary step its perfect disintegration by acids cannot be effected. Muriatic acid, however, takes up from it much iron, and the solution is precipitated by the ferro and ferrid-cyanide of potassium, so that it must include the two oxides of iron.

This mineral is obviously a massive magnetic iron ore, as is proved by the action of the magnet on it, by the iron being partially present as protoxide, and by the excess in the analysis, which arises from the entire of the iron being estimated in the form of peroxide.

As respects its commercial value, this will best appear by comparing the quantity of iron in it with that occurring in several varieties of clay ironstone.

	Per Centage of Iron.
Mineral from Rynvile,	27.32
Average of 10 Specimens of Scotch and Welsh Clay Ironstone,	31.55
Blue Flat of Staffordshire,	28.19

The amount of metal, therefore, in the Rynvile ore is *quam proxime* the same as that occurring in the variety of clay ironstone principally employed in Staffordshire, and not materially less than

the average of the richer ores of Wales and Scotland. It must, however, be admitted, that it is inferior to these ironstones in one important particular, viz., in containing a considerably larger amount of siliceous clay or gangue. It does, therefore, certainly not follow that, even though the necessary fuel were at hand, it could be smelted with the same facility, or that it would yield the same amount of profit.

In connexion with the economical question just adverted to, I may mention, that the magnesia which appears amongst the results of my analysis may probably be derived from the plates of serpentine which are interspersed through the ore, and which admit by careful manipulation of being separated from it. Assuming it to proceed from such a source, as the magnesia of serpentine constitutes on an average 40 per cent. of it, the magnesia of the mineral under consideration will correspond to 15 per cent. of serpentine; from which it is easy to calculate that 100 parts of the Rynvile ore, if carefully picked, would yield 32.14 of metallic iron,—a proportion much beyond the average of the clay ironstones smelted with profit in many parts of England and Scotland.

Not having been at Rynvile myself, I cannot speak with confidence of the geological position of the ore of iron. As well, however, as I recollect the verbal statement of Mr. Blake, it occurs associated with a vein of serpentine which traverses the mica slate of the district.

January 12, 1853.—"On an Analysis of Euclase;" by J. W. Mallet, Ph. D.

Euclase, from its transparency, delicate shades of colour, and perfect crystallization, is one of the most beautiful mineral species with which we are acquainted, and since it is at the same time a mineral of great rarity, good specimens of it form some of the most highly prized ornaments of mineralogical collections.

Such of the characters of the mineral as can be examined without injury to the specimens have been pretty accurately studied, especially the complex crystalline forms under which it occurs, which have been described at length by Hauy, Weiss, Phillips, and Levy. Our knowledge of its chemical composition, however, the investigation of which involves the destruction of the specimens operated on, depends upon a single analysis by Berzelius, as the numbers given by Vauquelin, the only other chemist who has ex-

amined the substance, are almost valueless, presenting a loss of about 30 per cent.

Though from the high authority of Berzelius as an analyst, any other investigation could scarcely be expected to yield results of much novelty, or differing materially from those he has given, yet a second analysis possesses some interest, even if merely confirmatory of his. The results of one which I have recently made, I wish, therefore, to bring under the notice of the Society.

The material employed for this analysis consisted of four fragments of crystals, weighing together about 20 grains. Though this is rather a smaller quantity than is usually taken for a mineral analysis, it was in the present case quite enough, as the constituents to be determined were but few, and alumina and glucina form a large proportion of the whole. These fragments were perfectly clear and transparent, three of them of a beautiful pale mountain-green colour, and one of a very light tinge of blue. They presented both natural crystal planes and faces of cleavage, and amongst the former were several adapted to the use of the reflecting goniometer. The mean results of some angular measurements over the obtuse lateral edges of four distinct vertical prisms were 115° 6′, 127° 51′, 140° 44′, and 149° 32′, all of which agree nearly with numbers given by Phillips. The only cleavage I observed was that parallel to the terminal plane replacing the acute lateral edge of the vertical prism, which is mentioned in mineralogical systems as the only cleavage easily obtained.

The specific gravity of these fragments was 3.036.

They were reduced to fine powder, and fused with the mixed carbonates of potash and soda, and the analysis was then conducted according to the usual routine for silicates. The alumina and glucina were separated according to the old method by carbonate of ammonia, as from previous experiments I found the use of caustic potash, which has been more recently proposed for this purpose, both difficult and uncertain. The analysis gave the following constituents per cent.:—

		Atoms.
Silica,	44.18	.950
Alumina,	31.87	.620
Glucina	21.43	.564
Peroxide Iron,	1.31	.016
Peroxide Tin,	.35	
	99.14	

These numbers agree very fairly with those of Berzelius, and, dividing by the atomic weights of the several constituents, give their equivalent proportions as in the second column. These are very nearly in the ratio

$$Si\,O_3 : Al_2\,O_3 : G_2\,O_3 = 8 : 2 : 2,$$

and hence we have the formula

$$2\,(Al_2\,O_3,\ Si\,O_3) + 2\,G_2\,O_3,\ Si\,O_3,$$

or if the two earths, alumina and glucina, be isomorphous,

$$4\,(Al_2\,O_3 + G_2\,O_3),\ 3\,Si\,O_3.$$

Scacchi, taking glucina as a protoxide, suggests an analogy between euclase and epidote, but if the corrected atomic weight of this earth be used, the formulæ of the two minerals differ widely.* If, on the other hand, alumina and glucina be isomorphous, the composition of euclase coincides with that of andalusite—

$$4\,Al_2\,O_3,\ 3\,Si\,O_3,$$

part of the alumina being replaced by glucina. An important objection to the idea of any real connexion between these minerals, however, arises from the fact, that they occur in different crystalline systems, andalusite belonging to the right prismatic, while euclase is in the oblique prismatic system.

There was one minor point in connexion with Berzelius' analysis which it was interesting to examine with special care, namely, the occurrence or not of a small quantity of tin in euclase, and I, therefore, took particular pains in testing all the re-agents for this metal before using them, and made a separate blow-pipe experiment on the mineral itself, with the object of reducing the tin directly. Even by the latter method there was no difficulty in distinctly ascertaining its presence, and there can, therefore, be no doubt of its really existing in the pure mineral.

The occurrence of traces of this metal in other silicates, as beryl, epidote, and a manganesian garnet, in meteoric stones, and in several ores of titanium and tantalum, has been remarked by different analysts, especially by Berzelius, and is certainly a very curious fact, when we consider the extremely small number of minerals in which tin forms a leading constituent, and the improbability of such minute quantities being essential to the composition of the species in which they occur.

* The angles of crystals of the two species also differ considerably.

"Notes on the Geology of the Southern Portion of the County of Cork;" by W. L. Willson, Esq., of the Geological Survey.

Mr. Willson exhibited the maps and rough sections of the Geological Survey of the southern part of the county of Cork. He commenced by stating that he meant briefly to lay before the Society a few of the results of his observations made in the field during the progress of the Geological Survey, with regard to the thickness, by measurement, of the rocks which intervene between the old red sandstone and carboniferous limestone at different points in the south and south-eastern part of the county. He then briefly alluded to a paper which had been read before the Society in March last, by Mr. J. B. Jukes, Director of the Survey, and called, "A Sketch of the Geology of the County of Waterford." In speaking of the Devonian rocks north of Dungarvan, Mr. Jukes remarks, "that the upper beds, or those which intervene between the old red sandstone and carboniferous limestone, were chiefly composed of sandstones; but near the top, beds of shales occur either red, yellow, or gray, and sometimes dark gray, the thickness of which he estimated at 700 feet. Mr. Jukes then goes on to say:—"But as we trace these beds towards the west, namely, from Dungarvan to Lismore, or from Ardmore to Youghal, we find the sandstones to diminish both in thickness and number, and the intervening shales to increase, especially in the upper part of the group." Mr. Willson then called attention to a small section which exhibited the thickness of this group of rocks, lying between the old red sandstone and carboniferous limestone on the northern coast of Ballycotton Bay, situated nine miles south of Youghal, and about twenty-five miles south-west of the point north of Dungarvan, which Mr. Jukes referred to in his paper. Commencing with certain beds of red slates and sandstones shown in section as the upper portion of the old red sandstone, and ascending, the following rocks occur:—1st, 500 feet of red and green shales and slates, with a few sandstones; 2ndly, 600 feet of greenish, gray, and brown grits, and yellowish-white flagstones, separated by bands of gray shale; and, 3rdly, 900 feet of gray and bluish-gray shales and slates, with a few grit beds occuring at intervals, on top of which apparently rests the carboniferous limestone, which is here very crystalline, and of a pale gray colour; the bluish-gray slates immediately beneath the limestone are, in places, calcareous;

thus there is a total thickness here of 2000 feet between the old red sandstone and the carboniferous limestone. Tracing these beds in a westerly direction, the strike being nearly east and west, they are found to form an unbroken line, passing close to the village of Cloyne, and from thence along the northern side of Cork Harbour to Queenstown, and so on, crossing the Cork river a little west of the latter place, to Monkstown on the opposite side, situated eighteen miles to the west of Ballycotton. South of the village of Monkstown another section of this group of rocks is seen: they are very much the same in the lower beds as at Ballycotton, but in the upper portion, consisting of bluish-gray slates, very similar to those on which the limestone seemed to rest at Ballycotton Bay; they are considerably thicker, about 600 feet, making a total thickness here of 2600 feet between the old red sand and the limestone. Tracing these beds again in a westerly direction, they are found to continue, forming a well-defined ridge of high ground to Ballinhassig, and from thence passing by Five-mile-bridge; and so on in the same strike to the north of Bandon, when the strike begins to change more to the south, and the beds arise in that direction, forming the northern boundary to the comparatively level plain which extends from Bandon to Dunmanway. In tracing these beds from Monkstown towards Bandon they are found to gradually increase in thickness, and also in extent, until at Ballinhassig they spread out, covering the large undulating tract of country lying between the latter village and Kinsale, bounded on the north by the high ridge of ground formed of the old red sandstone which extends from Monkstown in the east to Dunmanway in the west, and on the south by the sea and the headlands called the Old Head of Kinsale, and the Seven Heads, in the latter of which we find the old red sandstone re-appearing again, dipping to the north at a high angle. Mr. Willson then described a section which was drawn across this large tract of country, formed of these rocks which intervene between the old red sandstone and the carboniferous limestone. It commenced at a point four miles north of Bandon, and ended at the southern point of the Seven Heads, passing close to the town of Bandon, and the village of Courtmacsherry. Commencing at the point four miles north of Bandon, which is in the same line of strike as the Ballycotton and Monkstown sections, and taking certain beds of red sandstones and slates, shown in section to represent the upper beds of the old red sandstone, and

ascending in the section, the following thickness of rocks is observed, viz. 500 feet of dark purple and green slates, with green and dark-brown sandstones; 1500 feet of greenish-gray grits; yellowish-white flagstones, alternating with thick bands of greenish-gray shales; and 1800 feet of dark-gray and bluish-gray shales, often cleaned into fine slates, and worked for roofing purposes; with bands of gray grits occuring at intervals to the top of the group: making a total thickness here of 3800 feet, without coming to any limestone as at Ballycotton and Monkstown. These rocks, as shown in section, undulate and roll to the south, gradually attaining a greater thickness in that direction. Commencing now at the southern end of the section, viz. at the Seven Heads, where the old red sandstone re-appears with a reverse dip to that which it has at the northern end of the section; and taking certain beds of red slates, &c., to represent the same beds of the old red sandstone as those seen at the northern end of the section, and ascending in this section, the following thickness occurs:—1stly, 500 feet of dark purple and green slates, with green sandstones; 2000 feet of greenish-gray grits, and yellowish-white flagstones, separated by bands of gray shale and slates; and, finally, 2000 feet of dark-gray and bluish-gray shales and slates, with grit bands through them, occurring at intervals to the top, near to which the shales are often dark, almost black, soft, earthy, and calcareous;—making a total thickness here of 4500 feet of this group of rocks without coming to any limestone on top, so that there is no certainty that the uppermost beds of this series have been reached here. Commencing at Ballycotton Bay, situated thirty-five miles to the west of the Seven Heads, where the thickness was seen to be 2000 feet; and proceeding in a westerly direction along the same beds, we find a gradual increase taking place in the upper portion of the group, as at Monkstown, eighteen miles west from Ballycotton, there was a gain of 600 feet. Again, four miles north of Bandon, and thirty-five miles west of Ballycotton, there was a gain of 1800 feet, and from that point to the Seven Heads, about sixteen miles in a southerly direction, there was a further gain of 700 feet between these two north and south points, showing an increase in thickness of this group of rocks between Ballycotton Bay and Courtmacsherry Bay (or the Seven Heads section) of 2500 feet, and which must be taken as merely approximative to the upper beds at the latter place, from the absence of any limestone. In

conclusion, Mr. Willson begged to notice what at present seemed a curious fact regarding the great thickness of these rocks here, and the absence of limestone; namely, that at Macroom, about twelve miles north-east of the point north of Bandon, where this section was drawn from, limestone is seen to occur, and seems to rest upon a very thin band of the lower portion of this group of rocks,—viz. gray and greenish-gray grits, and yellowish sandstones. The greater part of these rocks (seen here to be 3800 feet thick) seems to be wanting at Macroom.

AT THE

ANNUAL GENERAL MEETING

HELD ON

WEDNESDAY, FEBRUARY 9th, 1853,

THE PRESIDENT,—ROBERT BALL, L.L.D.,

IN THE CHAIR,

The following Report from the Council was read and adopted:

THE Council have to offer to the Society the following Report for the past year.

During the past year fourteen new Members have been added to the Society, viz.:—Right Hon. the Chief Baron (rejoined); Rev. Richard Mac Donnell, D. D., Provost of Trinity College (rejoined); John Hamilton, Esq.; Gilbert Sanders, Esq.; John B. Doyle, Esq.; John J. S. Moore, Esq.; Samuel Gordon, M. D.; Robert Smith, M. D.; Richard Wolseley, Esq.; John Wallace, Esq.; William Clarke, Esq.; John England, Esq.; William Scott, Esq.; and George Henry Kinahan, Esq. (formerly an Associate).

The following Associate Members have also joined during the same period, viz.:—J. Pigot, Esq.; John W. Mallet, Esq.; William Smith, Esq.; Charles P. Cotton, Esq.; Thomas M'Comas, Esq.; Arthur Jacob, Jun., Esq.; Joseph Kincaid, Jun., Esq.; and John Haughton, Esq.

The Society has lost during the year, from death, and other causes, twelve Members, viz.:—Joseph G. Medlicott, Esq; George Wilkinson, Esq.; B. Mullins, Esq.; W. J. Collett, Esq.; William Fraser, Esq.; M. B. Mullins, Esq.; Colonel Bruen, M.P; Sir William Homan, Bart.; Thomas Brien, Esq.; Sir Philip Crampton, Bart.; Leland Crosthwaite, Esq.; and Sir John Macneill.

The present state of the Society as to numbers is as follows: 4 Honorary Members, 35 Life Members, 87 Annual Members, and 16 Associate Members; total amounting to 142 Members.

The Council refer with satisfaction to the increase in the class of Associate Members, as it is to this class that they look as likely in a few years to constitute a kind of reserve fund for the supply of active and practical workers in the field, and thus restore to the Geological Society of Dublin somewhat of the activity and zeal of its early days.

The financial difficulties to which the Council were obliged to refer at the last Annual Meeting have nearly disappeared, and, as will be observed by the accompanying balance sheet, the balance has been transferred to the proper side of the account.

This balance is, however, small, amounting to £2 11*s.* 5½*d.* In addition to this balance, the Society has standing to its credit in the public funds the sum of £95 5*s.* 3*d.*

The Council have carried out their intention of paying old bills before incurring fresh liabilities, and they are in a position to report that there is not a single outstanding account against the Society.

During the year the Second Part of Vol. V. of the Journal of the Society has been published, and the Third Part of the same volume is in progress, and will be issued to the Members during the summer.

The following List contains an account of the Donations made to the Society during the year.

DONATIONS

RECEIVED SINCE LAST ANNIVERSARY.

1852.

March 3.—Proceedings of the Liverpool Literary and Philosophical Society, No. 6. Presented by the Society.

March 3.—Returns of Agricultural Produce in Ireland, in the year 1850. Presented by the Commissioners.

March 10.—Quarterly Journal of the Geological Society of London, No. 29. Presented by the Society.

March 10.—Museum of Practical Geology.—Government School of Mines and of Science applied to the Arts.—On the Importance of special Scientific knowledge to the Practical Metallurgist, by John Percy. On the Science of Geology and its Applications, by Andrew C. Ramsay; and, On the Value of an extended knowledge of Mineralogy and the Processes of Mining, by Warington W. Smyth. The whole presented by Sir Henry T. De la Beche.

March 15.—Transactions of the Royal Scottish Society of Arts, Vol. III., Part 5. Presented by the Society.

March 17.—Institution of Civil Engineers.—Minutes of Proceedings, 1849–51; with a List of Members of the Institution, December 24th, 1851. Presented by the Institution.

April 7.—A Sketch of the Physical Structure of Australia, by J. Beete Jukes, M.A., F.G.S., &c. Presented by the Author.

April 14.—Two Sections of the Campagna Romana. By M. de Medici Spada, and Professor Ponzi. Presented by Thomas Hutton, Esq.

June 9.—Quarterly Journal of the Geological Society of London, No. 30. Presented by the Society.

June 9.—On the Original and Actual Fluidity of the Earth and Planets, by the Rev. Samuel Haughton, M.A. Presented by the Author.

1852.

June 9.—On the Causes which may have produced Changes in the Earth's Superficial Temperature, by W. Hopkins, Esq., M.A. Presented by the Author.

June 9.—Address delivered at the Anniversary Meeting of the Geological Society of London, on the 20th of February, 1852, by William Hopkins, Esq. Presented by the Author.

Sept. 20.—Athenæum.—Rules and Regulations, List of Members, 1850, and Donations to the Library, 1849; with Addenda for 1851. Also, Annual Report, &c., from 1st January, 1851, to 31st December, 1852. Presented by the Club.

Sept. 20.—Quarterly Journal of the Geological Society of London, No. 31. Presented by the Society.

Sept. 20.—Journal of the Royal Geographical Society of London, Vol. XX., Part 2; Catalogue of the Library, corrected to May, 1851; and an Address at the Anniversary Meeting, 24th May, 1852, by Sir R. I. Murchison, G. C. St. S., &c. Presented by the Society.

Nov. 3.—The Mastodon Giganteus of North America, by John C. Warren, M.D. 4to. Boston: 1852. Presented by the Author.

Nov. 3.—List of Donors to the Dublin University Museum and Herbarium, with a General Statement of their Donations, from May, 1844, to August, 1852 (two copies). Presented by Robert Ball, LL.D., Director of the Museum.

Nov. 3.—Fourth and Fifth Annual Reports of the Board of Regents of the Smithsonian Institution. Programme of Organization; Registry of Periodical Phenomena. List of Works published by the Smithsonian Institution. List of Foreign Institutions in Correspondence with the Smithsonian Institution (two copies). Abstract of the Seventh Census [of the United States]. Directions for Collecting, Preserving, and Transporting Specimens of Natural History. Message from the President of the United States to the two Houses of Congress, at the commencement of the first Session of the Thirty-first Congress, Part III. Report of the

Secretary of War, communicating Information in relation to the Geology and Topography of California. A Notice of the Origin, Progress, and present Condition of the Academy of Natural Sciences of Philadelphia, by W. S. W. Ruschenberger, M. D. (two copies). Map of that part of the Mineral Lands adjacent to Lake Superior, ceded to the United States by the Treaty of 1842 with the Chippewas. The whole presented by the Smithsonian Institution.

Nov. 3.—Sur le Pouvoir Magnétique des roches, par M. A. Delesse; Mémoire sur la constitution Minéralogique et Chimique des roches des Vosges, par M. Delesse. Presented by the Author.

Nov. 5.—Morse's Patent.—Full Exposure of Dr. Chas. T. Jackson's Pretensions to the Invention of the American Electro-magnetic Telegraph, by Hon. Amos Kendall. Presented by the Author.

Nov. 18.—First Biennial Report on the Geology of Alabama, by M. Tuomey. Presented by Henry W. Collier, Esq., Governor of Alabama.

Dec. 1.—Quarterly Journal of the Geological Society of London, No. 32. Presented by the Society.

1853.

Jan. 5.—Italian Irrigation; being a Report on the Agricultural Canals of Piedmont and Lombardy, by R. Baird Smith, F. G. S., &c. 2 vols., and a vol. of Maps and Plans. Presented by the Court of Directors of the East India Company.

Jan. 5.—Transactions of the Royal Scottish Society of Arts, Vol. IV., Part 1. Presented by the Society.

Jan. 5.—The Athenæum, 1852. Presented by the Editor.

Jan. 5.—The Literary Gazette, 1852. Presented by the Editor.

Jan. 5.—The Musical Times, Nos. 73 to 105; with a Catalogue of Music. Presented by the Editor.

Jan. 12.—Journal of the Royal Geographical Society of London, Vol. XXII. (1852). Presented by the Society.

Feb. 2.—Journal of the Society of Arts, Nos. 1 to 11. Presented by the Society.

Feb. 9.—Fossil Plant from the Coal Measures, Tipperary.

ADMISSION FEES.

	£	s.	d.
George M'Dowell, Esq.,	1	0	0
H. Medlicott, Esq.,	1	0	0
Rev. J. H. Jellett,	1	0	0
Rev. A. B. Rowan,	1	0	0
Alexander Jack, Esq.,	1	0	0
John Hamilton, Esq.,	1	0	0
J. B. Doyle, Esq.,	1	0	0
G. Sanders, Esq.,	1	0	0
John J. S. Moore, Esq.,	1	0	0
	£9	0	0

LIFE SUBSCRIPTIONS.

	£	s.	d.
J. Beete Jukes, Esq.,	10	0	0
Sir Henry De la Beche,	5	0	0
	£15	0	0

SUBSCRIPTIONS.

	£	s.	d.
G. M'Dowell, Esq. (1851–52),	2	0	0
H. Medlicott, Esq.,	1	0	0
Lord Talbot de Malahide,	1	0	0
Edward Wright, LL. D.,	1	0	0
Thomas M'Guire, Esq.,	1	0	0
A. M. Giles, Esq.,	1	0	0
H. W. Allen, Esq.,	1	0	0
John Patten, Esq.,	1	0	0
H. Bruce, Esq. (1850–51–52),	3	0	0
R. Barney, Esq., do.	3	0	0
A. M'Mullen, Esq. (1851–52),	2	0	0
Richard Griffith, LL. D. (1850–51–52),	3	0	0
Robert Mallet, Esq.,	1	0	0
E. J. Shirley, Esq. (1851–52),	2	0	0
C. W. Hamilton, Esq. (1850–51–52),	3	0	0
R. Hitchcock, Esq.,	1	0	0
J. Petherick, Esq.,	1	0	0
Dr. Harvey,	1	0	0
Carried forward,	£29	0	0
Brought forward,	29	0	0
Rev. Dr. Lloyd (1851–52),	2	0	0
E. Dawson, Esq.,	1	0	0
W. Dawson, Esq.,	1	0	0
Rev. J. H. Jellett,	1	0	0
W. H. Curran, Esq. (1850–51–52),	3	0	0
M. D'Arcy, Esq.,	1	0	0
Earl of Bective (1851–52),	2	0	0
J. Nicholson, Esq.,	1	0	0
Dr. Duncan,	1	0	0
Thomas Hutton, Esq.,	1	0	0
C. P. Croker, M. D.,	1	0	0
William Edington, Esq.,	1	0	0
W. W. Campbell, Esq. (1851–52),	2	0	0
S. Downing, Esq.,	1	0	0
J. Mollan, M. D. (1851–52),	2	0	0
Robert Ball, LL. D.,	1	0	0
John MacDonnell, M. D.	1	0	0
Carried forward,	£52	0	0

	£	s.	d.
Brought forward,	52	0	0
M. M. O'Grady, M. D. (1850–51),	2	0	0
James H. Hamilton, Esq. (1851–52),	2	0	0
Earl of Leitrim,	2	0	0
Rev. W. A. Willock,	2	0	0
Luke White, Esq.,	2	0	0
A. Jacob, M. D. (1851),	1	0	0
J. Apjohn, M. D.,	1	0	0
Earl Fitzwilliam,	1	0	0
Chief Baron Pigot, Composition,	2	0	0
Rev. the Provost,	2	0	0
Dr. Allman,	1	0	0
Robert Callwell, Esq.,	1	0	0
John Wynne, Esq. (1850–51–52),	3	0	0
The Archbishop of Dublin,	2	0	0
Rev. A. B. Rowan (4 years),	4	0	0
W. T. Wilkinson, Esq.,	1	0	0
George Yeates, Esq. (1850–51–52),	3	0	0
H. H. Head, M. D.,	1	0	0
Thomas Hamilton, Esq.,	1	0	0
G. Wilkinson, Esq. (1851),	1	0	0
Alexander Jack, Esq.,	1	0	0
F. M. Jennings, Esq.	1	0	0
F. J. Sidney, LL. D.,	1	0	0
Rev. J. Galbraith,	1	0	0
Rev. S. Haughton,	1	0	0
John Hamilton, Esq.,	1	0	0
Carried forward,	£93	0	0

	£	s.	d.
Brought forward,	93	0	0
John Purser, Esq.,	1	0	0
John B. Doyle, Esq.,	1	0	0
G. Sanders, Esq.,	1	0	0
J. Welland, Esq.,	1	0	0
P. Byrne, Esq.,	1	0	0
John J. S. Moore, Esq.,	1	0	0
Rev. Dr. Wall,	1	0	0
F. Codd, Esq. (1851–52),	2	0	0
Lieut.-Col. Portlock,	1	0	0
J. L. Whitty, Esq.,	1	0	0
Dr. Harrison,	1	0	0
John Radcliffe, Esq.,	1	0	0
Rev. Dr. Graves (1851–52),	2	0	0

Associate Members.

	£	s.	d.
W. Thornhill, Esq.,	0	5	0
J. Kennedy, Esq.,	0	5	0
G. Kinahan, Esq.,	0	5	0
J. Cogan, Esq.,	0	5	0
J. O'Kelly, Esq.,	0	5	0
A. MacDonnell, Esq. (1851–52),	0	10	0
J. K. Reid, Esq.,	0	5	0
James Pigot, Esq.,	0	5	0
J. W. Mallet, Esq.,	0	5	0
I. O'Mahony, Esq.,	0	5	0
A. A. Jacob, Esq.,	0	5	0
W. Smith, Esq.,	0	5	0
	£111	5	0

ABSTRACT OF THE TREASURER'S ACCOUNT FOR THE YEAR ENDING FEBRUARY, 1853.

Dr.

			£ s. d.
To Admission Fees,			9 0 0
— Life Subscriptions,	£15 0 0		
— Annual do.	111 5 0		
			126 5 0
— Half year's Interest to 5th April, 1852, on £80 12*s.* 3*d.*, 3½ per Cent. Stock,	1 6 2		
— Do. on £90 10*s.* 9*d.*, to 10th October,	1 9 5		
			2 15 7
			£138 0 7

Cr.

			£ s. d.
1852.	By balance due to the Treasurer on the last year's Account,		26 5 10½
April 7.	—By paid Printer's Account (per Draft 8813),		25 7 0
" 22.	—By sundry small expenses, per the Assistant Secretary's book,	£5 1 5	
	— Gratuity to house Servant,	1 10 0	
	— Cost of £9 18*s.* 6*d.*, 3½ per Cent. Stock, with Interest, &c. (per Draft 8814)	10 0 0	
			16 11 5
June 16.	—By Mr. W. Oldham's Account for Drawing and Engraving,	£5 15 0	
	—Expenses per Asst. Secretary's Book, (per Draft 8815)	7 4 10	
			12 19 10
Nov. 3.	—By Assistant Secretary's salary from 14th February to 14th August (per Draft 8816),		10 0 0
" 17.	—By Printer's Account (per Draft 8817),		23 7 4
Dec. 15.	—By do. do.	£3 11 10	
	— Expenses per Assistant Secretary's book, (per Draft 8818),	5 10 7	
1853.			9 2 5
Jan. 19.	—By Cost of £4 14*s.* 6*d.*, 3½ per Cent. Stock, with Interest, &c. (per Draft 8819),		5 0 0
	— Collector's Poundage,		6 15 3
	— By balance in Treasurer's hands,		2 11 5½
			£138 0 7

WILLIAM EDINGTON, *Treasurer.*

The following Officers for the ensuing year were then declared duly elected, and the Society adjourned to receive the President's Annual Address:—

President:

JOSEPH BEETE JUKES, M. A.

Vice-Presidents:

HUMPHREY LLOYD, D. D., S. F. T. C. D.
ROBERT BALL, LL. D.
LIEUT.-COL. PORTLOCK, R. E.
ROBERT MALLET, C. E.
JAMES APJOHN, M. D.

Treasurers:

WILLIAM EDINGTON, ESQ.
SAMUEL DOWNING, C. E.

Secretaries:

REV. S. HAUGHTON, F. T. C. D.
FREDERICK J. SIDNEY, LL. D.

Council:

RICHARD GRIFFITH, LL. D.
C. W. HAMILTON, ESQ.
JOHN MACDONNELL, M. D.
PROFESSOR HARRISON, M. D.
THOMAS HUTTON, ESQ.
ROBERT CALLWELL, ESQ.
PROFESSOR HARVEY, M. D.
REV. J. A. GALBRAITH, F. T. C. D.
JOHN KELLY, ESQ.
LORD TALBOT DE MALAHIDE.
PROFESSOR ALLMAN, M. D.
*GEORGE M'DOWELL, ESQ., F. T. C. D.
*REV. PROFESSOR JELLETT, F. T. C. D.
*EDWARD WRIGHT, LL. D.
*GILBERT SANDERS, ESQ.

ANNUAL ADDRESS

DELIVERED BEFORE THE

GEOLOGICAL SOCIETY OF DUBLIN,

FEBRUARY 16, 1853,

BY

ROBERT BALL, LL.D., M.R.I.A., &c., &c.,

PRESIDENT OF THE GEOLOGICAL SOCIETY OF DUBLIN; DIRECTOR OF THE DUBLIN UNIVERSITY MUSEUM;
SECRETARY TO THE ROYAL ZOOLOGICAL SOCIETY OF IRELAND;
PRESIDENT OF THE DUBLIN UNIVERSITY ZOOLOGICAL ASSOCIATION;
LOCAL SECRETARY, RAY SOCIETY; AND SECRETARY TO THE QUEEN'S UNIVERSITY IN IRELAND.

WHEN you did me the very high honour last year of electing me to be your President, I took the Chair with the expressed resolution on my part not to hold it longer, if I could make way for a person more suited for the office by a practical acquaintance with geology, as I consider that, in the present state of the Society, such knowledge is essential to him whose duty it is to guide you in your future progress. For myself, my avocation as a public servant for more than twenty-five years rendered the acquisition of any scientific knowledge difficult, and practical geology, in its special meaning, all but impossible. It is true, that I have read geological works; that I have some knowledge of collateral branches of natural science; and that I have had a very active share in the working of the Society, and have sedulously attended its meetings for seventeen years;—yet I have not had the practical application which, as I before said, I deem essential to your Chairman. It may be supposed that, as I have been placed on the retired list as a public servant, I should now have time to acquire the knowledge to which I refer; but I cannot do so in a year, and I do not purpose attempting it, believing that I can render better service to geology by promoting some of the branches of natural science to which my taste more inclines me; and, paradoxical as it may seem, looking forward to having less time for varied pursuits than I have yet had,

as I may now hope occasionally to engage in works such as the daily duty I was heretofore charged with rendered it idle to attempt.

For the year of my Presidency, and for some time before, I have had very close occupation, I may say without intermission; in consequence, my health gave way some three weeks since. I am still far from well; and have only within the last three days been able to think of an Address.

To follow out the example of my most excellent friend, your late President, Lieutenant-Colonel Portlock, and give not only a critical abstract of the papers that have been before you during the last year, but also an elaborate *resumé* of the progress of geological science throughout the world, calls for an amount of ability, information, and time, which was never at my disposal. But for the illness to which I have referred, I would have attempted a review of the sixteen papers which were last year before you;—I leave it to my talented successor as a debt due by this Chair, and rely on his good nature to clear it off in his next Address, with the view of keeping up the series of information as to our progress, to be found in the several Addresses, a practice by which the value of the various papers is much enhanced.

I have considered it right to say thus much of myself to prevent misconception, and also to plead in extenuation of the Address it is now my duty to make to you, and to deprecate comparison with those of the many able and learned men who have preceded me in this Chair, in which I shall ever consider it an honour to have sat.

Having thus informed you of what I am not going to do, I proceed to make an humble attempt, but I trust not a useless one, for the encouragement of the junior members of the Society, by showing them what they can do, may do, and (may I say?) ought to do. But first I would notice the origin of the Society;—it was founded in 1831, by the exertions of the late eminent and reverend Provost Lloyd, aided by other distinguished men; it was, as it were, an offshoot from the Royal Irish Academy, having the investigation of the mineral structure of the earth, and more particularly of Ireland, for its avowed object, one in which it has displayed a great amount of perseverance and zeal. And here I may remark, that not long since our unfailing friend, the father of our Society, and one of our first Vice-Presidents, Dr. Griffith, stated that he was one of the founders of the London Geolo-

gical Society, and that all the individuals who met together to form that Society were then alive. It is scarcely less remarkable that he, with the first Secretaries, Treasurers, and the fifteen Council of this Society, who were assembled together just twenty-two years since at the Provost's House,—twenty men, not then very young, are all in vigour at the present time, evidencing that geologists—with sound minds (which we cannot doubt)—have singularly sound bodies. To return from this digression to the working of the Society: we have records of 286 papers having been delivered at our meetings. It may well serve the object I have in view to mention them individually (see Appendix); they show the many able minds which have been engaged in promoting our objects, as well as the very varied subjects which have been treated of; yet, were there many times more, materials would not be exhausted (*acquirebat eundo*), one paper produces others, and not unfrequently a great mistake produces excellent information in discussion, and leads to the preparation of careful papers. Be not, therefore, afraid—if you do not teach, you may learn in the best school, i. e. in endeavouring to instruct others and to correct yourselves. Though we cannot hope to excel the zeal, perseverance, and energy of some of the early members of the Society, we may fairly hope to equal them; we have now our science on a better established basis, and each accession to it serves to open up sources not thought of in the former period; we have, therefore, the less excuse if we fail to make progress.

It has been ignorantly said, that the Government Survey has been doing, under our Presidents Portlock, Oldham, and our new President, with their able assistants, all that this Society contemplated. With all respect for the talents of our friends and their aids, they did not, they will not, and they do not pretend to take charge of all the work we cut out for ourselves, and if they did, they could not do it. Doubtless, by them will be laid down the broad and comprehensive chart which will guide the course of future geologists, who, if prudent, will not trust too far. Opportunities daily arise which the Survey cannot have; by these individuals may correct the maps, and step by step improve the great work towards which the indefatigable exertions of Dr. Griffith had made such wonderful approach. I feel quite assured that the officers of the Geological Survey will heartily thank any of our members who, in

a philosophical spirit, may even attempt to point out facts which they may observe in sinkings or cuttings, and which may not have fallen under the notice of the Survey. I thus urge you to measure hammers with this formidable government service, but should you not dare to do so, there is ample room for you to take a wide berth and advance geology in many ways. It is a science embracing so much, that I believe I am correct in saying, that there lives not a perfect geologist armed at all points; such panoply is not for one man; but what one man cannot do, a society may do; we include zoologists, botanists, mineralogists, chemists, meteorologists, geographers, physicists, &c.; the new-coined palæontologist ought to be a zoologist and botanist tolerably perfect, i. e. skilled in a knowledge of organized beings recent and fossil; the latter can only be properly understood by means of the former, while the zoologist and botanist who does not know extinct species is but half made up. The labours of the various members to whom I have referred, being brought into the common stock, will in time come to be combined in a harmonious whole by some master mind. In the early time of geology, crude hypothesis in the closet was the occupation of learned cosmogonists; now, those who work at home use the facts which those occupied in the field accumulate; thus the structures they raise, based on facts, are permanent, while the products of erudite but visionary brains have passed away. I know many think it difficult, if not impossible, to teach generally how to observe. The difficulty will usually be found to exist in preconceived notions in the pupils; I consider that few persons of ordinary intelligence can be found who might not usefully observe. If they will set themselves to carefully describe what they actually see, and no more, they will soon find their powers increase, and learn to be accurate; a facility of making useful deductions is not so easily acquired, but if the young geologist will content himself with perseveringly accumulating facts, without immediately doing so to support any preconceived idea of his own, the true bearing of these facts will, sooner or later, burst upon him. Is there any one amongst us who cannot do something in our service? I think not. Those who are near fossiliferous strata may collect specimens of their organic remains. If merely in the old-fashioned way, it is a pretty and healthful recreation, but for geological purposes the greatest care is necessary to note the locality and the relative numbers of species, their respective posi-

tions in the beds, &c.; even without these scientific additions the general collection of fossils is useful in training the eye of the naturalist to the distinction of species.

Within a short distance of Dublin many palæontological questions remain unanswered; such as the distribution of shells in the carboniferous limestone, their varieties, and the probable causes on which these varieties depended. In the drift a search for arctic shells is well worthy of attention, as is the discovery of shell marls, newer than the glacial drift, but associated with it.

A careful collection of the bones of vertebrate animals, wherever they may occur in bogs, marl, gravel, as indicating remote antiquity, is much urged; it is but a short time since that the former existence of bears in this country was contradicted on historical evidence, supported by the fact that no remains had been found. It is only very lately that we have had unquestionable evidence of very large bears having existed coeval with the giant deer of Ireland, apparently the carnivorous restrainer of the increase of that mighty ruminant. It is but a few years since the remains of rein-deer were found in quantity close to Dublin, yet, doubtless, both bears and rein-deer have left in our marls many of their bones, which, for want of knowledge, have not before attracted attention.

The microscope opens up a fine field of discovery, and I believe one not at all sufficiently worked. The study of the entomostraca, both recent and fossil, is replete with pleasure, and, probably, if fully pursued, would be found to lead to as sound diagnosis in geology on certain points, as the study of the larger fossils. Baird's book, published by the Ray Society, and Jones's, by the Palæontographical, would suffice to point the way to an inquirer in this direction.

As regards the structure of rocks much remains to be done in examining in minute detail the metamorphoses, such as may be found on the flanks of the granitic district of Wicklow:—the subjects of slatey cleavage; of the foliation of various schists; and the difference between cleavage and the separation of crystalline plates. The nature of many igneous rocks has never been explained.

A well-digested arrangement of rocks, founded, probably, on the chemical constitution, is most desirable, and many years of exertion may be well bestowed on it. Its want is felt by the field geologist; it is a stumbling block in the way of the application of economic

geology, and it leads to great confusion in discussions, as we have often witnessed.

It appears to me that electricity in its various forms may be used experimentally to much advantage in aid of geology. Modifications of the electrotype processes may, I expect, afford much help to inquirers in this direction. There is in the University Museum the remains of what was once a miner's pick; the iron is all gone, and in its stead is a mass of native copper; while along the handle, which is still quite sound, are crystallized minerals; the whole affording evidence of active processes still at work, and capable of modifying the distribution of metals in a very remarkable manner.

Members who have opportunities may render our Transactions more valuable by contributing reports of mining operations, and will find much scope for earnest application in metallurgical pursuits. Though these can scarcely be called geological, yet they are so nearly connected as to be quite within our objects, and the history of metallurgy will show that no applications of science are more important than those it requires.

When we reflect that it is probably owing to the exertions of our elder brothers in London, and our own here, that geology has come to be recognised by Government and the public, and that it is now taught in our time-honoured University, in the three provincial Colleges, in the Dublin Society, and, through its operation, in various towns through Ireland, as well as disseminated all over the country by the operation of the Geological Survey,—we may fairly feel proud of the share we have had in such a result, and may look forward with more than hope to the great increase of the Society from the springs of geological knowledge which have been thus opened within a very few years. Our founders would have rejoiced could they have anticipated such a power as I have alluded to, and they would naturally have speculated on great results. Shall we not have them? If not, it will be as discreditable to us as their great advancement, under many difficulties, was honourable to them.

It is right to warn young geologists against the mischievous class of persons called *cui-bono* people, who, though they endeavour to decry inquiry where a useful end is not seen, too often successfully snatch the benefits from those who arrived at them by exercising the highest privilege and most glorious occupation of man,—

the search for truth for its own sake. It is in such search that I look for any great step in geology. Those who inquire, with a definite end in view, may be said to have half discovered it already; while experience shows us that the mighty progress of recent time is the result of the application of truths discovered by philosophic labour, rarely undertaken with any view to such application. I therefore urge the search for truth; every truth found adds to human power; and in geology ascertained facts are the implements necessary for progress.

Besides your scientific exertions in the cause of the Society, there are other aids which you may render, such as inducing suitable persons to join it. If each of you bring in one you will enable the Council to publish more, and will probably do a real service to your friends. You may have perceived, by the Report of the Council, that the progress of the Society has been steady; debts have been cleared off; the numbers of the Society have increased; and, on the whole, a fair promise for the future is given. It remains with you to realize still greater success. Will you work? If you will, gird on your hammers, and to the assault forthwith.

In leaving the Chair I must again express my sense of the high honour I have had to have filled it. I would have gladly complied with the wish that I should have continued to do so if I did not think it my duty to the Society to endeavour, by my retreat, to secure for you the services of my excellent and able friend, Mr. Jukes, Director of the Geological Survey of Ireland. To overcome his scruples was my greatest difficulty; in the which your generous desire to do me honour made me more earnest. It appears to me that the spirit of the law of the Society is, that changes should be made in the Presidentship as often as practicable. Hence the restriction to two years as a maximum; besides, I find two precedents for one year, viz., Colonel Colby, in 1837, and Dr. Griffith, in 1840. The rule, as a general rule, may be a good one, but in my case I felt in myself a want of that special knowledge which you will, I am sure, understand more fully when you find the increased spirit which will necessarily manifest itself from the practical experience of your Chairman, whom I now beg to instal, with hearty good wishes, and a feeling that he will experience from your hands the same courtesy and kindness I have always received, and for which I am most grateful.

March 9, 1853.—"On the Queen's County Collieries;" by ARTHUR A. JACOB, C. E.

THE Leinster coal formation extends over a large tract of country, including portions of the Queen's County and of the counties of Kilkenny, Tipperary, and Carlow. It has been deposited upon and is conformable with the mountain limestone, and overlies the latter to a considerable depth. The entire district is surrounded by flat-topped hills: thus, a basin is formed, to the centre of which the beds uniformly incline. There are, of course, several exceptions, due to local disturbance.

I have selected for this evening's paper the parts situate in the Queen's County. This part is bounded to the north by Cullenagh, to the south by the Kilkenny coal district, to the east by Ballylinan and Ballickmoyler, and to the west by Ballinakill and Ballyroan.

The outcrop of the lower beds of sandstone belonging to the coal measures can be seen in but few places, owing to the deep alluvial deposit with which they are covered. It is very clearly defined in the neighbourhood of Ballinakill, on the edge of the Castlecomer road, and also at Cullenagh, where it is inclined to the horizon at an angle of 7°,—the strike being N. 22° W.

The principal collieries are the Doonane, Newtown, Towlerton, Nuragh, and Rushes: in all these the coal called the 3-foot seam is chiefly sought. This seam is not of a regular thickness, being sometimes less than two feet thick. This change, and the variable quality of the coal, has led to the supposition that the coal found in the Rushes colliery is not the same seam as that found in the Newtown. I have carefully examined these collieries, and am satisfied that I am correct upon this point, as reference to the sections will show.

There are, as far as I can discover, in the district included upon the map (Towlerton excepted), four regular beds of coal,—all anthracite: viz., the foot-coal, which is the lowest bed; over it the 3-foot coal, then the double seam and at top of these the 9-inch seam. I will proceed to describe them in their proper order.

The foot-coal is but of little value, and only worked near the outcrop; it underlies the 3-foot seam, at a depth varying between twenty-five and forty-five yards.

The 3-foot seam is of considerable value, and has been much

worked. Unfortunately, owing to the careless manner in which this seam was formerly wrought, a great portion of the coal has been lost; and, now that the supply is nearly exhausted, the proprietors have at length had their eyes opened, and are carrying on their works in a more systematic, and, of course (comparatively speaking), in a more profitable manner.

Owing to the method formerly adopted, the whole country is studded with pits,—they being sometimes not more than sixty yards apart. The hurrying roads were so very defective that the coal could not be carried to the shafts for any considerable distance. Pillars of enormous size were also left, which, now that the coal is becoming scarce, are being removed; but the expense of re-opening the collieries for the purpose is very great, and, consequently, none but the shallow parts are searched.

The double seam, as far as I could find, occurs only in the Rushes and Newtown basins. It is composed of two beds of coal,—each bed being about one foot in thickness, having a bed of fire-clay of one foot between them: it is not wrought, as the quality is inferior.

The outcrop is only visible in the Furnans quarry, where the beds are highly fossiliferous.

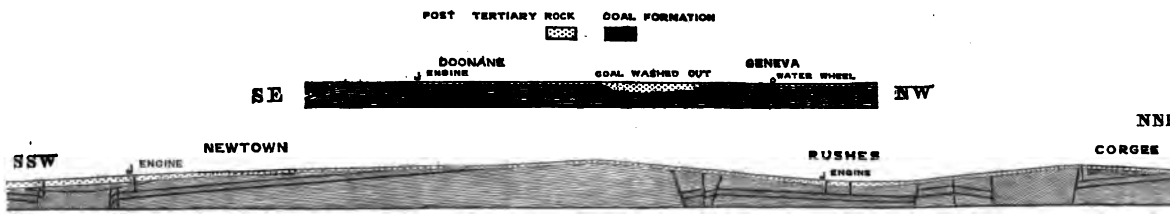
The 9-inch seam only occurs in a few places, and can hardly be considered as a regular bed: it thins out sometimes to two inches, but in no place is it thicker than nine inches. Each of these beds of coal is underlain by a bed of fire-clay of very superior quality; it is generally about three feet in thickness. It is strange that such a source of wealth should have been neglected, when its removal from the collieries would have considerably facilitated the excavation of the coal, and when its great value was pointed out so far back as the year 1814 by Mr. Griffith, in his able Report on the Leinster coal district.

Mr. Edge, some short time since, erected a kiln, and burned some bricks, which were quite as good as those imported from the English collieries; he did not, however, exert himself to obtain a market, and as soon as he had made what he required for his own use he gave up the manufacture.

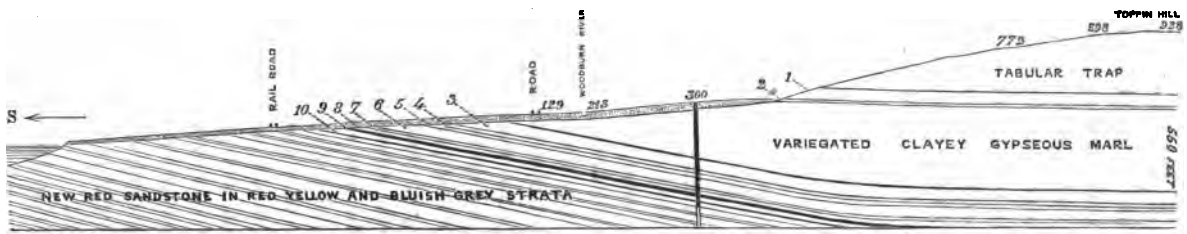
Mr. Wandesforde, the owner of the greater part of the Kilkenny coal field, has erected a brick and tile factory at Castlecomer, and though he uses the common brick clay of the neighbourhood

SECTIONS TO ILLUSTRATE MR. JACOB'S PAPER ON THE LEINSTER COAL-FIELD.

SCALE, $\frac{1}{25200}$



SECTION TO ILLUSTRATE MR. DOYLE'S PAPER ON THE SALT MINE AT DUNCRUE.



1. Chalk.
2. Greensand.
3. Saliferous Beds, 100 ft.
4. Red Rock Salt, 22½ ft.
5. Workable Saliferous Deposit, 26½ ft.
6. Pure Rock Salt, 84 ft.
7. Mixed Rock Salt, 14½ ft.
8. Pure Rock Salt, 39 ft.
9. } Ironstone, Freestone, Grey Rock not
10. } yet bored through, 22 feet.

in large quantity, he has never, as far as I could discover, given the fire-clay a single trial. The land in the coal district is in general of fair quality, but (owing to a very retentive subsoil) it is of little value unless thoroughly drained. It is only within the last few years that the drainage system has been adopted, and the consequent improvement is visible to the most casual observer.

To understand the geology of the entire Leinster coal field would require years of study and careful examination, which I am sorry to say I cannot devote to it; but should these remarks lead others to examine into our native industrial resources, I will feel that I have done my duty.

March 9, 1853.—"Notes on the Salt Mine at Duncrue, and Searches for Coal by the Marquess of Downshire;" by J. B. DOYLE, Esq.

THE scene of the present operations in search of coal by the Marquess of Downshire lies about two miles north-west of Carrickfergus, and about a quarter of a mile from the valley of the Woodburn River, in the middle division of the county of the town, at a point about 300 feet above the level of the sea.

The entire of the Antrim coast presents a series of mural precipices, against which there abuts an extensive mass of vegetable soil, descending to the very margin of the sea, with inclinations more or less steep, according to the distance. This recumbent mass is generally of great thickness, as in the present instance, and is formed of the *debris* of adjacent rocks and the beds of the gypseous marls of the new red sandstone formation, which lie between the mountains and the sea.

The order of the strata is very plainly developed in the face of the escarpments, and consists of tabular trap, resting upon the white chalk and greensands, beneath which are the lias and new red sandstone series.

The new red sandstone is not very common in Ireland, being principally confined to the basaltic formation of the north, and to a small district in the County of Monaghan, in the vicinity of Carrickmacross.

Its principal development in Antrim is in the valley of the

Lagan, and at Carrickfergus, on the north shore of Belfast Lough. The series has been computed to be from 1800 to 2000 feet thick, consisting of a large proportion of shales.

The sandstone strata are very thin, and are variously coloured,—the reddish-brown predominating, intermixed with others of a bluish-gray, green, or yellow colour.

The same formation is traceable on the shores on the opposite side of the Lough, between Cultra and Hollywood, where thin beds of magnesian limestone alternate with the new red sandstone beds. The limestone is much denuded by the action of the sea, as it all lies below the high water-mark.

On the Antrim side, the beds attain a considerable elevation: the general strike of the strata is to the east, dipping north.

As the new red sandstone lies immediately above the coal measures in England (where the formation attains its greatest expansion), it has become one of the special sites of manufacturing enterprise. Not less than seventeen or eighteen principal cities and manufacturing places are situated on it, or upon the strata belonging to it.

It is no wonder, then, that in a district so remarkable for manufacturing enterprise as the north, repeated trials for coal should have been made from time to time, hitherto without success. The present researches are the most important and extensive that have yet been made, and are being pushed forward with an energy worthy of a successful result.

In the pursuit of this desirable object, a discovery of great interest and value has been made. About 600 feet from the surface an immense bed of the purest rock-salt has been penetrated, the entire series of the saliferous beds exceeding 200 feet in thickness. The salt has been pronounced to be of a very superior description, yielding from 95 to 98 per cent. of pure salt of commerce.

Some of the salt beds are of a beautiful blush colour, others white, and those mixed up in the shale bands are sometimes bluish or of a clayey-brown appearance.

As we have not had a previous opportunity in this country of making our acquaintance with the arrangements of this system, it may not be uninteresting to the members if I were to give the results of the borings at present in progress, which have now reached

the depth of about 900 feet, being nearly 600 feet below the level of the sea.

I am indebted to my friend Mr. Kelly, a distinguished member of this Society, for the following memorandum, made at the edge of the shaft upon the 10th September last, at which time the greatest depth obtained was about 700 feet:—

	Feet.
Diluvium, about 50 feet; red marl, 500; intermixed with thin beds of gypsum, ...	550.0
A thin stratum of rock-salt, ...	15.0
Salt and blue band, ...	6.8
Pure salt, ...	88.0
Blue and red band, with some salt, ...	17.0
Mixed salt, blue and red band, ...	13.0
Last salt, clean, but not yet bored through, ...	20.0
	709.8

These salt beds, from a very careful examination, are found to be conformable with the strata of the formation on the surface; so that it may fairly be concluded that the deposit is not a lenticular mass, confined to a single basin of limited extent, but a regular series of stratified beds: and if so, it is not difficult to calculate upon the out-crop at no great distance. The line of section, p. 231, is taken from the Toppin Hill, 928 feet above the level of the sea, running through the mouth of the shaft nearly due north and south to the Lough. This would give the out-crop about a mile and a half to the east, as nearly as may be ascertained from a section taken within the shaft.*

The probability is, that there are many such beds along the whole area of the new red sandstone formation, as it is well known that gypsum has been found at Colin Glen and at Cushendall. At Larne, as I have been informed by P. M'Garel, Esq., of the Maheramore Limeworks, borings were made in search of coal in the year 1839, of which a return has been forwarded; from which it

* A Company for working the salt mine has been recently formed in Belfast, and are now sinking a shaft near the Railway Terminus, very nearly in the place indicated above.

appears that thin beds of salt were reached at only 150 feet below the surface. These experiments were made in the town of Ballyedmond, about three miles from Larne, and near to the village of Glynn, where a salt spring has been known to exist for years. The salt reached was only eight yards thick; but, as the borings were discontinued at the depth of 174 feet, it is more than probable that the great deposit lies farther down. Between this point and the mine at Duncrue, at the village of Eden, there is another salt spring, which would lead to the supposition that the whole district between Larne and Carrickfergus, at least, contained a saliferous deposit. Since these notes were first made, a new salt mine has been discovered at Red Hall, lying within this district. But coal is the great object to be obtained. Reports of its discovery have appeared from time to time in the Belfast papers; but hitherto they have all proved fallacious, or at least premature.

I have obtained a Report of such a circumstantial nature, given by the engineer conducting the operations at the mine, that I am induced to give it: it wants verification, however, which I have taken steps to obtain. The borings are given as follows:—

Taking the gypseous marls as before, . . .		550
There follows, of workable saliferous beds,	100	
A stratum of red salt, ...	22¼	
Then a saliferous deposit, ...	26	
Pure salt, ...	84	
Mixed rock-salt, ...	14½	
Pure salt, ...	39	
Total saliferous, ...	——	286
Thin blue band, ...		6.6
Dark-coloured rock resembling ironstone, . .		4.0
Freestone, ...		10.1
Gray rock, not yet through, ...		2.4
Total, ...		859.1

One very favourable indication is present,—all the strata, so far, are conformable, which, according to Professor Sedgwick, is a very probable indication of the series running out into the coal measures.

In England, where the system is most perfectly developed, it

presents the following series of beds, according to the same high authority, viz.:—

UPPER BEDS, SUNK 600 FEET.

1. Variegated marls,—red, bluish, greenish,—with laminated clays, holding gypsum generally, and salt partially, as in Cheshire.

2. Variegated sandstones, the lower parts in some districts pebbly.

MIDDLE, 300 FEET THICK.

1. Laminated limestone, with layers of marls, gypseous and mottled.

2. Magnesian limestone.

3. Marl slates, soft and impure.

LOWER SERIES.

Red sandstone, red and purple marls, micaceous grits,—white, yellow, or pebbly.

"Where conformable," he adds, "this sandstone passes into the coal measures, upon which it rests."

How far all these members of the system may exist in the new red of the Antrim district will be a matter for examination.

The magnesian limestone, as we have already observed, is found alternating in thin beds with the new red on the shore near Cultra, in the county of Down; and perhaps a more careful examination of the same district will detect others of the series.

Another encouraging circumstance may be referred to. In the Tyrone coal field, near Dungannon, the new red sandstone rests upon the coal, unconformably, however; and although more extended observation establishes the conclusion that there is no determinable order applicable in all cases as to the nature of the rock that overlies the coal,—as it may sometimes be a slate clay as well as a sandstone,—yet, in reference to the efforts now being made, it is so far encouraging to know that not only is there no impossibility, but there is a strong probability, of a successful result, founded upon the geological conditions already noticed.

April 13, 1853.—"On the Quartz Rocks of the Northern Part of the County of Wicklow, by JOHN KELLY, Esq."

WHEN the Ordnance Geological Map of the county of Wicklow was published, it appeared to me that one of the sections accompanying that map was erroneously conceived and drawn; that is the section passing in a north-westerly direction through the Great Sugarloaf near Bray. In that section there are shown above twenty beds of quartz rock alternating with slaty rocks, and this I look upon to be a mistake. It was with a view to get this corrected that I put together the observations in the present paper, and describing such facts as my memory supplied, to show that the views I entertained were borne out by those facts.

After the paper was written I gave it to Mr. Oldham to read, previously to giving notice of its being read in this Society, that he might be prepared to defend the views put forward in the section, but immediately after, he made arrangements to quit this country, and the subject dropped. However, if the section be incorrect, as I believe it to be, it is well to correct it at any time.

As the subject of this paper lies chiefly in the northern part of the county of Wicklow, it may be well to give a short description of the rocks in that vicinity.

The rocks of Bray Head belong to the lower part of the old graywacke series, which is now called "The Cambrian rocks" by the English geologists. They occur generally in well-defined beds, of a hard, gray, coarse-grained, siliceous rock, averaging two or three feet in thickness, those often alternating with beds of gray slate, or red slate, only a few inches thick. This hard gray rock has recently got the name of "quartzite," but this name must not be confounded with "quartz rock," which here is of a whitish yellow colour, and totally different from quartzite in mineral character as well as in colour. The quartzite beds are sometimes five, ten, or fifteen feet in thickness, and the slaty beds as much, but these cases are the exceptions to the general rule.

Quartz rock in Ireland occurs in two different conditions, stratified and amorphous. Stratified quartz rock occurs abundantly in Donegal, Mayo, and Galway counties. The unstratified or amorphous kind occurs also in those counties in certain localities; but it is this kind that chiefly occurs in the counties of Dublin

and Wicklow, and also at Wexford. Both kinds might be got in hand specimens, extremely similar to each other in colour, fracture, and texture, but, as seen on the great scale where they occur in the country, the two kinds present a striking difference.

I shall select one or two particular districts for description. Stratified quartz rock is found along the northern coast of Mayo, stretching from Broadhaven eastwards to Glenlossera, a distance of fourteen miles, and extends from the shore inland from three to five miles, thus comprising an area of above fifty square miles. This is called the Glenamoy district, from the river of that name which flows through it. Here on the shore the stratification is well exposed, and the beds beautifully regular, averaging from ten to fifteen inches in thickness, having micaceous partings, by means of which they are easily separated into large flags, having remarkably smooth surfaces. The rock in this locality appears not to have been much disturbed. It dips pretty uniformly at a small angle, about 15° to 25° to the south-east, and under mica slate, thus showing it to be older than the mica slate of that district of Mayo.

In Donegal, the stratified quartz rock is found in contact with, and lying upon granite at rather a small angle in several places, namely, near Malin Head and Dunaff Head, in the barony of Innishowen; in Kilmacrenan barony near the coast, north of Rossnakill; at Glen; between Ballyness Bay and Claudy river; on the summit of Bloody Foreland mountain, the north-western part of the county; again at Maghery, three miles south-west of Dunglow, and in the island of Arran, altogether forming a line of junction with granite of above thirty-five miles in length. The quartz rock in most of this line is stratified, the beds dipping at a low-angle to the south-east, and succeeded by mica slate, conformably; all showing the quartz rock here also to be older than the mica slate.

Since granite comes in contact with every rock occasionally, no reliance can be placed on this long line of junction for determining the age of the quartz rock; but the fact that it is found both here and in Mayo,—dipping conformably under the mica slate, in such extensive areas,—is a proof at least, that it is the oldest stratified rock in either of those counties.

A second band of quartz rock occurs in Donegal, a few miles from this first, and parallel to it. It is four to five miles in breadth, and above forty-five miles long, extending from Culdaff, by Carn-

donagh, Buncrana, Rathmullan, and Letterkenny, and ending near Fintown. A band of mica slate separates those two bands of quartz rock. Along the north-west margin of this second band some of the dips would indicate that it succeeds the first mica slate conformably, and on its south-east margin it is succeeded by what has the appearance of a second mica slate, which extends over the south-eastern half of the county, and also into Londonderry and Tyrone. Whether there be really two distinct bands of quartz rock, or whether the second is an upthrow of the first, bounded on the north-west margin by a long, straight line of fault, cannot easily be determined. The latter is probably the case, as this north-west margin is nearly in a straight line with the edge of the granite district, from Ardara to Fintown, produced north-east in the strike of the stratified rock.

Such a fault would produce the appearance of two bands of quartz rock here, where only one formation really existed; for the granite, hot, liquid, expanded, and elevated, would have cooled and hardened first round its external margin, at the junction with the other rocks, and gradually inwards towards the central axis of the ridge. While this gradual cooling and consequent shrinking were going on, the central parts would have dropped down by those fissures, as the mass contracted more than the exterior, where it first cooled and became solid; and this would account for those two bands of quartz rock, *that* next the granite having slipped down with the granitic nucleus, and left the external margins on a higher level.

Something of this kind may be traced in the county of Dublin, in the limestone district. All the beds of limestone in the level country from Donnybrook, by Rathgar, Kimmage, Crumlin, the Fox and Geese, &c. &c., dip towards the granite, which lies southward, instead of being found in the horizontal position in which we must presume they were originally deposited.

In the neighbourhood of the Glenamoy district, at the west side of the great lake of Carramore, amorphous quartz rock occurs in the townland of Rathmorgan. Here it rises into a large hill, 768 feet above the level of the sea; and this makes a striking feature where the surrounding country is rather flat. What is worthy of remark here is the occurrence of this amorphous mass in the vicinity of the low, flat, and stratified district of Glenamoy, leading to the inference of a common origin here for both kinds of this rock;

that the hill has been protruded from a lower level, through the overlying strata; and that it originally formed part of the base of the great mass, though now found in contact with and even on a higher level than the superior beds which surround it.

The quartz rock of this hill appears to be identical in character with the quartz rock of the Sugarloaf district of Wicklow, of Howth, and of Forth mountain in Wexford. They are all of the same yellowish white colour, the same fracture, the same aspect, and the same general absence of sedimentary lines.

I do not mean to say that quartz rock is not found interstratified with mica slate; on the contrary, thin bands of quartz rock, from ten to fifty feet in thickness, are often found alternating with beds of slate. They occur so in numerous instances in the neighbourhood of Clifden in Connemara, and also in Glenamoy in the county of Mayo, near the junction of the quartz rock and slate district; but generally downwards from the junction, in the quartz rock, there is no slate seen, and the overlying slate contains no quartz rock. The cases where they are interstratified are few, and might be called the exception. In all these bands there is no doubt of the true sedimentary character of the rock, the beds being distinctly visible. What I would endeavour to show is, that the quartz rock of the Sugarloaf district in Wicklow is not of this kind.

From the foregoing facts I infer, that the quartz rocks of the Sugarloaves and Howth are not like those alluded to in Mayo and Donegal, in their original position with regard to the adjacent rocks; that they do not alternate with them, as shown in the Ordnance section through the Great Sugarloaf, but that those great masses, now brought in this locality to the surface, were once joined to, and formed a part of, a regular system of stratified quartz rock lying below the gray slaty rocks, as they are now seen in Mayo and Donegal; that they were in this position rendered semifluid or plastic by subterranean heat, and protruded through enormous fissures made in the overlying graywacke by volcanic or other expansive power from below; that the sedimentary lines of the former beds have in a vast majority of cases been wholly obliterated, but that in a few cases faint traces of such lines are still visible, as they are in other metamorphic rocks, which are believed to have been in a semifluid state, and yet bear slight marks of former stratification, such as porphyries, slaty greenstones, and even granite itself, which in some

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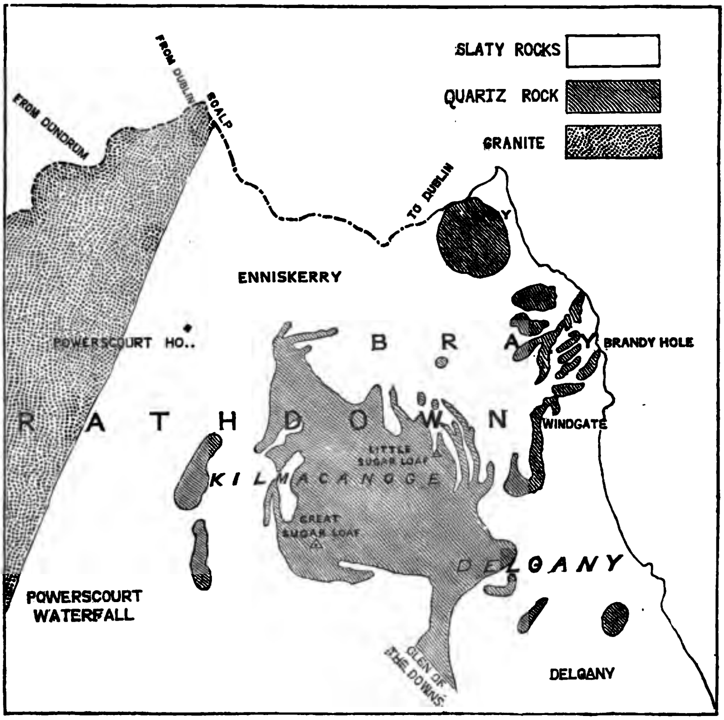
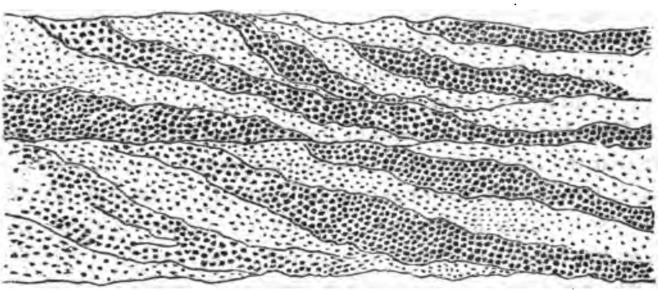


localities shows decided traces of bedding, and the interior of the beds is of coarse crystallization. This latter fact may be well seen in the townland of Dunlewy Near, on sheet 43 of the Ordnance Map of Donegal.



Stratified Granite at Dunlewy Near. Sheet 43, Donegal.

Any one who looks at the accompanying map of the vicinity of the Wicklow Sugarloaves will see, from the extent and form of the several masses, and the spurs and forks emanating from the main body of the quartz rock of that locality into the adjacent graywacke, that they never could have been produced by ordinary sedimentary deposition.

Though, perhaps, not a strong point to be relied on, yet it may be mentioned, that the rugged outline of Bray Head bears a strong resemblance to the outlines of many ridges of hills in Donegal, in the vicinity of greenstones and porphyries in that county, and more especially in the neighbourhood of Rathmullan.

Stratified quartz rock, such as occurs in Donegal, Mayo, and Galway, is not found in Wicklow, so far as I know; but since it is generally under the slaty rocks in those counties, there is no good reason to suppose it is absent here. It may be, and probably is, under the slate in Wicklow, as well as in Mayo.

From Rathcoole, by Dunlavin to Castledermot, the slaty rocks generally dip S.E., and the accumulation of the strata is from the Chair of Kildare towards Dunlavin, the upper beds coming in contact with the granite on its western margin here; and it is remarkable that on this side there is no quartz rock. So also from Aughrim and Carnew, southward through Wexford, it is the upper part of the slaty rocks that lies in contact with the granite of Mount Leinster, and there is no quartz rock there; thus following up the ana-

logy in Mayo and Donegal, before alluded to, of the absence of quartz rock in the upper part of the slaty rocks. But in the north of Wicklow, about the Sugarloaf hills, the case is different. Here the rocks belong to the lowest strata of the Cambrian group, as before stated.

Along the granite border from the Scalp, near Enniskerry, to Roundwood, the gray stratified beds of rock dip south-east, from Bray Head by Newtownmountkennedy they dip north-west, in the contrary direction; thus forming a synclinal valley along the line from Roundwood to Bray: and in the bottom of this synclinal trough it is that the largest masses of amorphous quartz rock in Wicklow, that is, Drumbawn, the Sugarloaf hills, and the masses about Bray Head, make their appearance. In the protrusion of those great masses the superincumbent strata were uplifted and fractured, and the whole of the upper part of the slaty rocks corresponding with that on the Dunlavin side was carried away by denudation, leaving only part of the Cambrian strata behind, which is now well exposed in the railway cutting at Bray Head; those strata intermixed in a confused way, but not interstratified with the amorphous quartz rock masses of that vicinity as we see them now.

I shall now enumerate the principal masses of quartz rock in the south-east of Ireland, and afterwards notice such facts in the vicinity of any of them as bear upon the subject. They are—

1. The Hill of Howth, a roundish mass, about two square miles.

2. The mass in which are the Greater and Lesser Sugarloaves, about four square miles. This mass is rudely circular, and is the largest in Wicklow.

3. Shankill, near the Scalp, a long, narrow mass, about half a square mile.

4. Bray Town stands on one of those protrusions. The form of it is nearly circular, and it is about one-fourth of a square mile.

5. Bray Head. This is a long, narrow mass of rock, forming a fork at the south end. It is about a mile in length by from a furlong to half a furlong in breadth, making one-eighth of a square mile.

6. The Brandy-hole protrusion, half a mile south of Bray Head, a long, narrow, crooked, irregular mass, about one-fourth of a square mile.

7. Walker's Rock, an elliptic mass, lying half a mile west of the Great Sugarloaf, and occupies an area of about one-eighth of a square mile.

8. Drumbawn, a low district, about two miles N.W. of Newtownmountkennedy. It occupies about one and a half square miles.

9. Dunran Hill, three miles south of Newtownmountkennedy, an irregular roundish mass, about three-fourths of a square mile.

10. Rathmore, crosses the mail-coach road two miles north of Ashford. This is a long, narrow strip like a dyke, in area about a quarter of a square mile.

11. Carrickmacreilly. The quartz rock in this mountain is mostly formed into long, narrow stripes, some a mile long by half a furlong in width; frequently a row of hummocks in a line, with hollows between them. There are several masses, which in the aggregate occupy about half a square mile.

12. Ballinacor mountain, five miles south-west of Rathdrum; about one square mile.

13. Forth Mountain, running from the town of Wexford to the south-west, comprising an area of about twenty-two square miles,—the largest in Leinster.

Besides the above there are numerous others; indeed, there may be counted on the Ordnance Geological Map of the county of Wicklow two hundred and ninety-eight of these small masses, lying in the slaty strata along the eastern boundary of the granite, and in its vicinity. Those small masses are generally shown as of a lenticular form, about half a mile in length by a few perches in width. They are shown lying lengthwise in the strike with the slaty beds, thick in the middle, and getting smaller towards the ends, and agreeing in shape exactly with the greenstone protrusions and elvan dikes, which also are marked in the vicinity of the granite, and appear to take the places of the quartz rock masses as they proceed towards the south from Aughrim to Carnew. Indeed, on the Ordnance Map it appears that the Aughrim river, which runs eastward by Arklow, and in the line of which there is shown a great fault or shift, cuts off the Cambrian rocks and the accompanying quartz rock masses near the granite, and divides them from the upper Silurian rocks, with their accompanying elvan dikes, which seem to be the protrusions of these latter rocks, and which lie all to the south of this place in contact with the granite, as the Cambrian do northward from that place to Killiney; thus showing that the quartz rocks are associated with the lower

part of the graywacke or Cambrian rocks through all the district. It is the same about Forth mountain in Wexford.

I shall now be more particular in describing a few of the separate masses, and begin with one of the most remarkable, that which is seen on the shore half a mile south of Bray Head, at the Brandy-hole, a name well known to the country people since times when smuggling was practised. There is a good section of the rocks here, in the cutting for the Wicklow railway, at the mouth of the Brandy-hole tunnel. The quartz rock at this place resembles a great bed, about fourteen yards in thickness. It lies conformably with the stratified beds, and dips conformably with them to the N.W. at an angle of about 60°; and certainly, if examined only at this spot, a geologist at first sight would pronounce it a bed of rock, regularly deposited in order, with the beds in contact with it, and not a dyke or protrusion of plastic or fluid matter. But dykes of foreign matter are frequently found running a long way between two beds of rock. Trap dykes are seen at Scrabo quarries in the county of Down, in sandstone, and at Carlingford in limestone, running in this manner between two beds, preserving an exactly uniform thickness for several yards in length, and then turning suddenly away in another direction through the quarries, cutting across other beds.

In the mass of quartz rock at the Brandy-hole there are no traces of stratification. From this place it passes westward up the hill, forming a rough, elevated crest, and rises, at half a mile distance from the shore, to a height of 793 feet, thence it descends to the village of Windgate, which is a mile from the shore. In this mile the mass preserves the long, attenuated form of a dyke, but in width it is very irregular, and so far unlike the true beds about Bray Head. It varies from 14 to 50, 100, and in some places 150 yards in thickness. In this course also, though preserving the same general direction, it is disturbed in its continuity, apparently by horizontal shifts. There are two places, as may be seen on the map, where it is only a few yards wide, and a third where it is quite separated at the surface of the ground from the rest of the mass, which soon rises up again, forming a steep, rough rock. When the observer arrives at Windgate, he will find that the mass does not pursue the direct course across the road, as might be expected in following it from the shore, but takes a turn southward, crossing the strike of the graywacke beds, which here lie at both sides of it,

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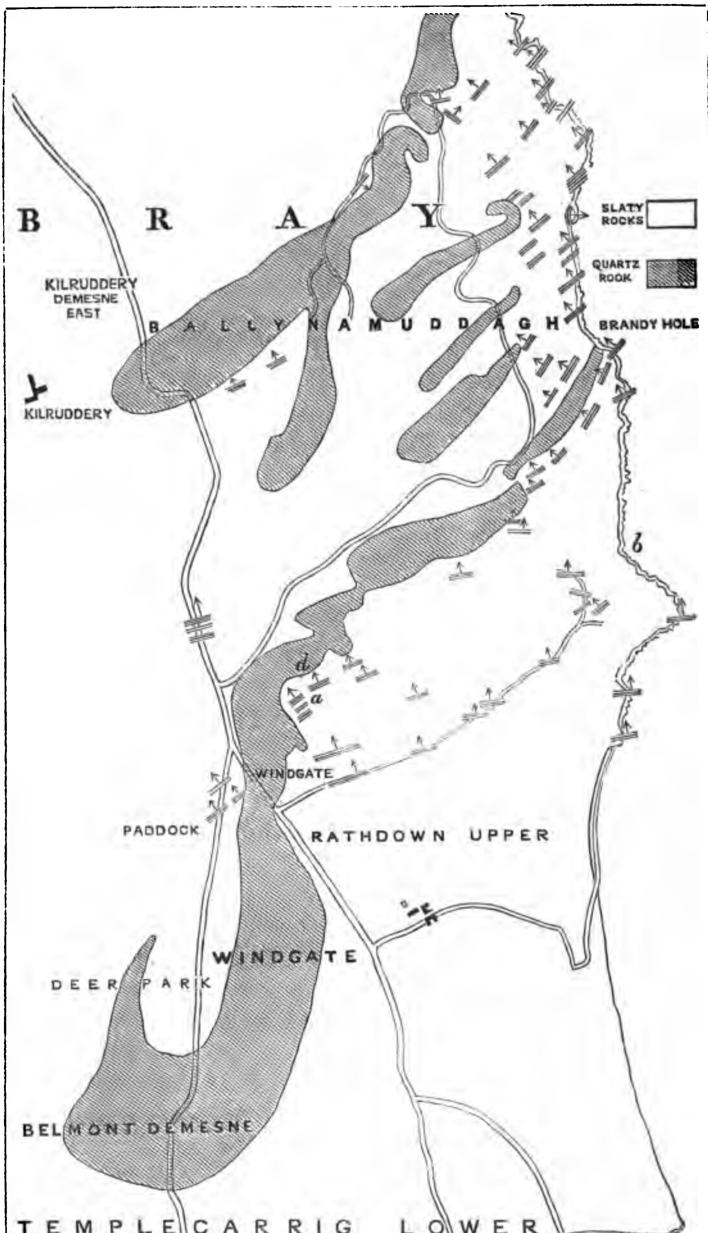


and are well exposed to the eastward, between it and the shore. From this turn southward it increases in bulk, forming a hill 532 feet above the level of the sea, and 200 yards wide across at the summit. It then descends southwards, through Templecarrig Lower, into the valley, then turns westward under Belmont House, and thence northward through the plantation, where it terminates in a narrow point.

Now, this Brandy-hole quartz rock mass is one of my strongest facts to show that this quartz rock is not in its original natural position, but is an intruded mass, although at the sea-shore it appears to lie in the gray Cambrian beds conformably.

In the area which lies to the south of this mass, and between the shore and Windgate, the strike of the beds is nearly east and west, and the dip 60 to 80 degrees north, both being persistent and regular over this area of nearly a mile, in its east and west direction, by a quarter of a mile average width, from north to south. The beds in the northwest angle of this area are broken off, and at Windgate village, where the quartz rock takes a turn to the south, it overlaps their broken ends, and separates this area from another area of similar rock lying west of the road, thus forming a great intruded mass of yellow unstratified quartz rock, between the two fields of stratified gray rock, and, as was said before, cutting across them, and separating them—and bearing some resemblance in idea to the skeleton of a horse, the backbone being represented by the quartz rock, and the ribs by the graywacke beds, aiming at and striking against it on both sides.

It might be argued, that at Windgate, where the quartz rock mass takes a turn southward, nearly at right angles to its former course, the stratified rocks turn also with it, and bend parallel to it, all forming a curve together; but this is not the case. Take the point *a* on the accompanying map, where the stratified rock is visible, and follow the strike eastward to the shore at *b*; from this point *b*, where the strike cuts the shore, to the Brandy-hole, is about sixty perches. If the stratified rocks curved round, to conform to the shape of the quartz rock, there ought to be this distance of sixty perches between where the stratified rock is seen at *a*, and the next quartz rock, which is seen at *d*: this is a space in which no rock is seen; it is a tilled field, the rock being covered with gravel and soil, but it is clear that even if the beds did turn

round here, there is not room between the point *a*, where the stratified graywacke is visible and persistent with that of the area lying eastwards, and the point *d*, the nearest quartz rock visible which, is only seventeen perches off here, while the thickness of graywacke beds which should fit in this space, if there were no break in them, and that they turned round in the angle, should be above fifty five perches. In fact the mass, in its progress from the Brandy-hole to Windgate, in its general direction shifts southward a little across the strata, cutting the ends obliquely at a small angle, but from Windgate southward, where it takes the turn, it cuts across the beds nearly at right angles. This could not have been the case if the quartz rock mass had been deposited in a sedimentary way, with the gray beds.

It will be understood from these observations, that according to the views I take, this mass of quartz rock is a protrusion of the rock, in a plastic or semifluid state, through orifices or fissures made by subterraneous movement, in the solid rock which lay over it. From the general shape of the mass, and the manner in which it lies with the accompanying well-defined stratified beds, sometimes parallel to them, and sometimes breaking through, and crossing them irregularly, I cannot come to any other conclusion; besides I have more facts to draw upon in support of these views.

A glance at the map, where the dips and observations are all marked in their proper places, will show all that relates to this important mass, better than further description.

The Bray Head protrusion lies about half a mile north of the Brandy-hole ridge, and is nearly similar to it in length, breadth, and general form. It rises from the shore to a height of 653 feet, and, forming a row of hummocks, presents a rough irregular outline, passes westwards down the hill to Ballinamuddagh village. At this place it throws off a branch to the south-west, which forms a fork with the main line. This branch terminates at 120 perches from where it sets off, and the main line ends in the valley of Kilruddery demesne.

Near the summit of this ridge, convenient to Bray Head, there are two low passes through the narrow, steep quartz rock ridge, and these are occupied with slate; but they have each the appearance of being only a thin, superficial patch, stretching across the hollow, and joining the greater mass of slate on both sides of the ridge.

Between the Brandy-hole ridge and the Bray Head ridge, in the townland of Ballinamuddagh, there are three small masses of quartz rock, which are pretty much alike in size and form; a description of one of them will serve for each. The middle one is about 350 yards in length, 88 yards wide at the west end; 66 yards in the middle, and 50 yards at the east end. It has the appearance of lying in the stratified beds conformably, being parallel to the strike; but if a sedimentary bed, the two ends of this mass would be prolonged in an attenuated form, and end in a point, which is not the case. At each end the termination is rather abrupt, and the mass is not produced eastward to the shore, because, if it were, it would appear in the line of railroad, which is only 30 perches from it, and where all the beds of the hill are visible, being cut across, and this yellow bed is not where it should appear if produced. The railroad is only 150 yards from where they disappear on the north-east brow of the hill. There is little doubt but those three small masses lie in the strata, and are partially conformable with them, and if so, the apertures which received the plastic matter from below were made by a separation of the beds along the sedimentary joints, with some fracturing of the strata at the ends where they terminate abruptly.

The quartz rock mass of the Great and Little Sugarloaf hills, as before stated, occupies an area of about four square miles, and within this area, as shown by outline on the map facing p. 241, I believe no slate exists. The two hills are included in this mass, as well as the space between them, and round their bases for some distance.

As in most geological sections, the Ordnance section passing through the Great Sugarloaf passes across the strata, nearly at right angles to the strike. In seeking, therefore, in the country for an exhibition of the alternations of quartz rock and slate, shown on that section, an observer would naturally follow the strike of the beds; that is, proceed either in a S.W. or N.E. direction, to some ravine or place where the rock should be well exposed. A favourable place of this kind is found in the valley through which the road runs westward from Kilmacannoge chapel towards the waterfall. The direction of this road is east and west, and across the strike of the rocks of the district, and as it runs along the northern brow of the Great Sugarloaf mountain, this is a place where, if those alternations existed, they would be visible.

Draw a line from the trigonometrical station, on the summit of the Great Sugarloaf, to Kilmacannoge chapel. This line has a north-easterly direction, and is nearly in the strike of the stratified beds of the surrounding country; and not far from the average of the direction of the eastern slope of the mountain itself, which is shown to be the last or most easterly bed of quartz rock on the section. This same bed, then, should be found at or near the chapel, and westward from it on the road side should be found the alternations which are shown upon the section; but not one of them is there to be found for half a mile west of the chapel, or until we get beyond the distance from the chapel, that the alternations are shown to exist westward from the summit of the mountain.

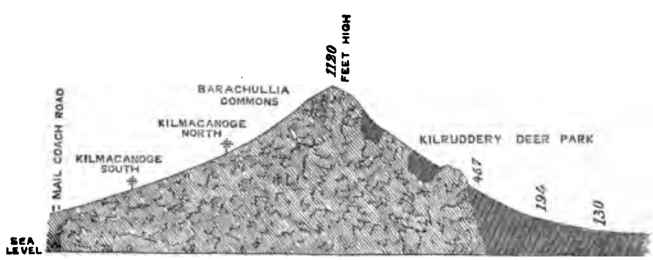
Again, it may be said that those alternations of slate exist in lenticular masses, and disappear in wedge-shaped points, before they reach the Kilmacannoge road. Take the line of section itself, and westward on this line for about twenty-five chains, or 100 perches from the summit, all the rock seen is quartz rock; but in this 100 perches distance from the summit, on the section, are shown nine bands of slate, alternating with as many bands of quartz rock; and since no slate is found in this distance on the ground, I think the section is incorrect.

There are indeed two longitudinal, rib-like masses of quartz rock on the west slope of the Great Sugarloaf, with slate between them, which might suggest the idea of alternating bands of quartz rock and slate; but these are not separate masses,—though they are separated by a band of slate in one place, they are joined and unite in another. I look upon them to be low ridges of the quartz rock, thrown up in relief on the edges of small faults or fissures in the underlying rock; and that the slate here is not alternating with them, but lying in thin superficial patches between them on the subjacent quartz rock of the mountain; the same way as it is seen on the eastern slope of the Little Sugarloaf, or on the summit of the Hill of Howth.

Another circumstance I think incorrect is this:—On the map the eastern slope of the Great Sugarloaf is all coloured as slate, with three very small lenticular masses of quartz rock in it. On the corresponding section the whole of the eastern slope of the mountain is shown as quartz rock. The map and section do not agree.

The east side of the Little Sugarloaf hill deserves some notice. The top of this mountain is quartz rock. Descending from this on

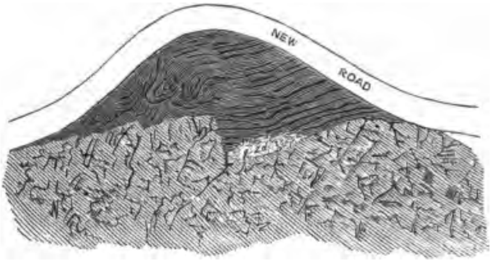
the east side, the rock continues downwards 120 yards. Then comes graywacke, and gray and red slate, dipping westwards into the hill, and about 100 yards thick; next a mass of quartz rock 125 yards; again, graywacke and slates as before, 140 yards, and dipping like the former at an angle of 70 degrees westward into the hill. The next is a prominent mass of quartz rock, about 80 yards thick, and from the lower side of this, to the valley, about 120 perches distance, no rock is visible, but slaty gravel is seen in the ditches. If alternations of graywacke and quartz rock are to be had, *this section is like them*, but the two bands of gray rock and slates thin out to a wedge-like point southwards, and the three bands of yellow quartz rock grow narrower at the surface northward, and terminate; and those alternate bands, therefore, though well seen on the slope of the mountain, are not alternating beds of rock, but quartz rock in its plastic state, which in its ascent got entangled with the masses of slate, and so lifted them to their present position. Those two very different rocks are, therefore, not interstratified with one another, but each one separate and independent of the other, thus forming the zig-zag junction shown at this place on the map. A section also conveying this idea is given below.



Section through the Little Sugarloaf Hill; Line East and West.
Scale of length, 2 inches to a Mile.

The junctions of those two rocks, where visible, are interesting. At all these, a man might stand with one leg on the quartz rock, and the other on the gray stratified rock, they come so abruptly together, and without any gradual passage from one into the other. A junction is visible at Ballinamuddagh, near the summit of Bray Head, at 100 yards south of the trigonometrical point shown on the Ordnance Map, and close by the side of the new road made by the

Earl of Meath. The slaty beds here are seen cut or broken across, with their ends abutting against the amorphous mass of quartz rock, nearly at right angles to its side. A plan of this is given.



Plan showing Junction of Quartz Rock and Gray Slate at Ballinamuddagh, near the summit of Bray Head. Scale, 10 paces to an inch.

Proceeding southwards from the place just mentioned, along the Earl of Meath's new road, at about 300 yards' distance beds of rock are again seen on the road-side, the strike and dip very clear, the strike being nearly at right angles to the axis of the Bray Head protrusion.

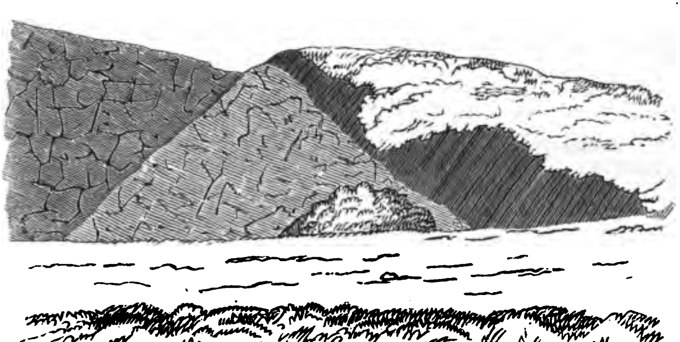
The unconformability of the graywacke beds and quartz rock would be much clearer in this district, but at the junctions of the two rocks there is generally a depression in the slate, owing to a tendency to decomposition at this place, the beds being much softer immediately at the junction than elsewhere, while the quartz rock retains its usual hardness in all parts. A good example of this softness in the slaty rocks is visible at the railway cutting near the Brandy-hole tunnel.

Here the slates, lying immediately over the quartz rock, are so soft for twenty feet away from the hard mass, that specimens taken at a considerable depth below the surface may be cut with a knife, some are grayish, some are red, but the prevailing colour of those soft slates is yellow, as they are seen lying on the quartz rock mass at the mouth of the tunnel. This yellow soft slate may have been altered, either by calcination from the vicinity of the incandescent quartz rock, or by the action of water, which is continually percolating through the loose fragments of the slaty mass in heavy rains. The latter is probably the chief cause, since the slates which lie under the hard mass of quartz rock are not soft, to anything near the same degree as those which lie over it.

Other localities in the district show the softness of the graywacke and slate rocks, at the junction with the quartz rock. In the cutting made to form the Earl of Meath's new road in Ballinamuddagh, near Bray Head, where this road crosses the three quartz rock protrusions before mentioned, such junctions are seen. In forming the road, the workmen, finding the material soft in certain spots, dug pits, and followed it into the side of the hill, to get stuff for making the surface of the road. Those pits are all in the slate at its junction with the quartz rock.

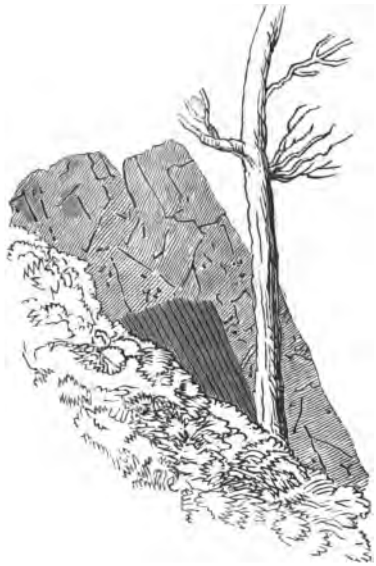
The softness, and the fragmentary condition of these slates at the junction, near the Brandy-hole and other junctions, are arguments in favour of the idea that some disturbance took place at those junctions since the original deposition; and that the quartz rock masses have been intruded, and were not originally deposited in the position in which we now find them.

At Ballydonagh, half a mile north of the Glen of the Downs, on the side of the road leading to Windgate, a junction of quartz rock and graywacke is visible, in which the slate lies unconformably on the hard rock. A sketch of this is given.

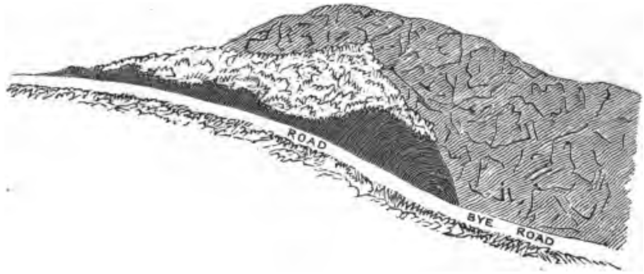


View showing Junction of Quartz Rock and Clay Slate on the Road-side at Ballydonagh, 3 miles south of Bray.

Something like veins of quartz rock are occasionally seen; at the Dargle, a mass of this kind, of long narrow form, occurs. It has all the appearance of a vein or dike emanating from the main body of the Sugarloaf mass. The steep rock called the Lover's Leap is on it. This is shown in the following view.

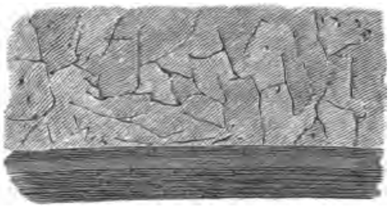


View in the Glen of the Dargle, near Bray; about two chains east of a Cottage on the high bank, south side. Here the junction of Quartz Rock and Gray Slate is unconformable.



The first of these two cuts is a view—the second a section of a junction of quartz rock and gray slate, a quarter of a mile west of the summit of Bray Head.

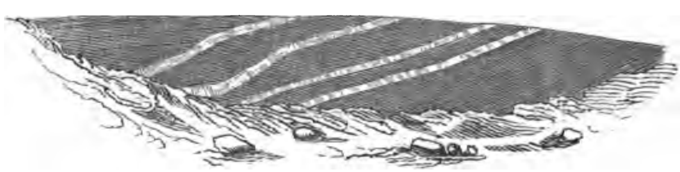
In the above drawing it is seen that the mass of yellow quartz rock is not conformable with the slate, but lies across the ends of the beds.



View of Quartz Rock lying on Slate, in the Glen of the Dargle, near Bray, south side.

Here the quartz rock joins the slaty beds conformably, and this fact tells rather against my views, but I shall not conceal anything.

Though not in the district, I may mention that, at Kellystown, two miles south-west of Wexford, near Rathaspick Church, a quarry has been opened. The rock here is chiefly gray slate, but there are four veins in it of grey quartz rock, and it is for these, as building stone, the quarry has been opened. Those veins are each about a foot thick. They lie nearly parallel to each other, and though nearly in the strike, yet they are not conformable with the slaty beds. A drawing of these is given herewith, which shows more

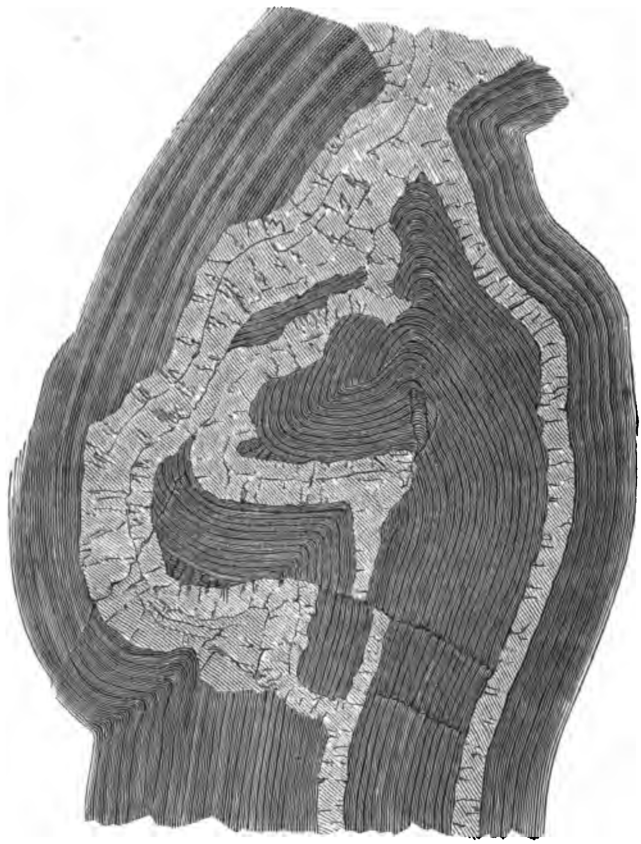


View, showing Veins of Quartz Rock, in Gray Slate at Kellystown, 2 miles south-west of Wexford.

clearly than can be shown by words how they lie with regard to each other, and to the strata. The lowest of those four veins, so far as it is exposed, lies quite conformable with the slaty strata; the upper one is not conformable anywhere, and the two intermediate ones are conformable with the accompanying strata in the upper part of them, and unconformable in the lower.

It has been stated that the Hill of Howth, which is of quartz rock, is composed of a series of alternations of graywacke with gray

and red slate, interstratified with beds of sand, which beds afterwards became hardened, and are now the quartz rock we see. I cannot accord with this view of the structure of that Hill. I have never seen any facts to induce me to believe that sedimentary alternations of graywacke and amorphous quartz rock are to be found anywhere. The quartz rock of Howth occupies an area of about two square miles. It is rudely circular on the plan, and appears to have been once a great cylindrical or perhaps rather conical mass, having graywacke on the top, and quartz rock below. That this whole mass was forced up by some expansive power from below, through the surrounding strata, of other kinds of rock, which skirt it round on every side. The line of coast from the Bailey Lighthouse towards the harbour runs north-east. It is parallel to the edge of the quartz rock, and it is in the strike of the graywacke beds, which dip away from that quartz rock at a very steep angle. So far there is nothing remarkable, but from the Bailey Lighthouse westwards along the coast are to be found the most extraordinary contortions, both vertical and horizontal, to be seen anywhere in strata. The beds are folded, both in elevation and in plan, in a manner certainly not to be accounted for by any imaginable process in ordinary natural deposition. They stand nearly upright, but they may have lain, and probably did once lie, horizontally on the mass of quartz rock, at a great depth; and as the mass of the hill was forced up vertically, those beds were broken off, one portion resting on top of the quartz rock mass, while the adjacent portions of the beds were uplifted towards a vertical position, being crushed and contorted in the vicinity of the moving mass.



Plan, Quartz Rock and Slate, near Howth, immediately east of the Needle Rocks. Scale, 8 yards to an inch.

Among a variety of examples, which may be seen on the southern shore of Howth, the foregoing figure is a plan of a spot, a few yards to the east of the Needle Rocks, which has been carefully surveyed. By inspection of the plan it will be seen that the graywacke beds are frequently broken across, and their ends overlapped by the yellow rock; so also on the west side in this plan, the ends of the slaty strata are broken off, and thus broken come in contact with quartz rock, while in other places where the beds are contorted, the quartz accommodates itself to them conformably, and lies in bands of equal

thickness, parallel to the sedimentary beds. The yellow rock here, like the mass at the Brandy-hole tunnel, appears to have been protruded through the slaty rocks in a semifluid state. There is no other possible way for accounting for the appearances. Bands occur of uniform thickness for several yards in length, sometimes parallel to the strata, sometimes cutting them across at right angles, and irregularly in the same manner as greenstone dikes do. In the larger masses, such as the Hill of Howth, the Sugarloaves, and Forth Mountain, although the stratification is obliterated in general, yet there are masses of the rock often seen, which show faint traces of sedimentary lines, leading to the conclusion that those masses were once regularly stratified, but subsequently altered. The smaller bands, however, do not present the slightest appearance of sedimentary lines.

I stated before that I considered the quartz rocks of Mayo to be of two kinds. Adding to the appearances, then, those in Wicklow, there would be three kinds of quartz rock; they are:—

1. The stratified rock, the original sedimentary arrangement of which appears never to have been altered. It occurs in masses of great thickness, as was said before, in Donegal, at Culdaff; it is well exposed on the shore and at several other places in that county; in Mayo on the shore for many miles in the Glenamoy district of Erris; and in Galway thinner bands about Clifden in Connemara.

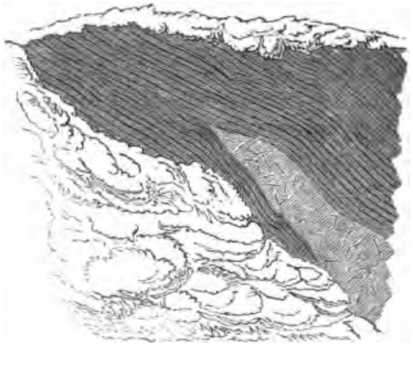
2. The amorphous quartz rock. This lies chiefly in Leinster, the Hill of Howth, the Sugarloaves in Wicklow, and Forth Mountain in Wexford, masses also of very great thickness. Generally speaking, in this, the sedimentary lines are obliterated, but instances occur where faint traces of stratification are still visible, as at Walker's Rock, a mile west of the Great Sugarloaf, and two miles south of Enniskerry; also in the quartz rock immediately south of the town of Wexford, parallel joints on a large scale appear, which may be connected with the original stratification.

3. That kind of quartz rock which appears to have been protruded into fissures in the overlying gray rock. Such are seen in the contortions at the Needle Rocks, Howth; the Brandy-hole mass, already described, with other masses thereabouts; at Rathmore, two miles north of Ashford, in the hill of Carrickmacreilly, and many other places. In this kind I have never been able to detect any trace of stratification.

These three kinds of quartz rock are identical, at least in external characters: they are of the same colour, hardness, and fracture, and a hand specimen of one of them cannot be distinguished from that of another.

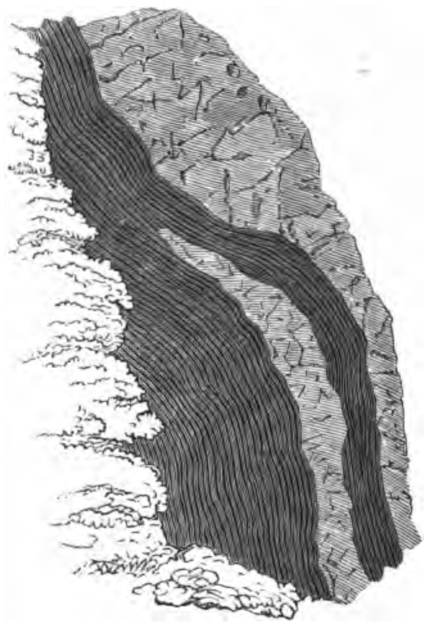
Objection is made to this view by the chemists, who say that quartz rock is not fusible before the blow-pipe, nor can it be affected by the ordinary tests used to reduce other rocks. This may be the case; but the Great Chemist who did this work is able to bring to bear upon His subject conditions not in the power of man. He can command any amount of heat; any amount of pressure, with the use or exclusion of air, water, gases, electricity, and other agents, to effect His object.

If the quartz rock of Leinster be an altered condition of such stratified quartz rock, as we find in Mayo, as I believe it to be, in which condition the sedimentary lines, so clear in Mayo, are obliterated, or nearly so in Wicklow, this obliteration of the lines of stratification must have been produced by a certain degree of softening of the original rock, say, to make it plastic. This degree, carried a little further by the same agency, would make it liquid, so that it would flow into any fissure in an overlying mass of unaltered rock that lay convenient when the great weight of a superincumbent mountain pressed upon it. In this manner I suppose the Brandy-hole mass was protruded; the openings in the contorted masses at Howth filled up, and smaller veins injected as at Kellystown and various other places.



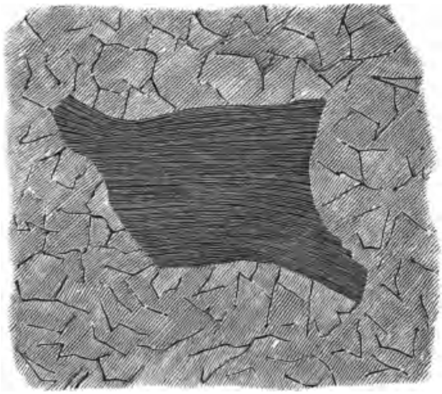
View of Quartz Rock and Slate immediately south of the Town of Howth.

The view on the preceding page shows the upper part of a quartz rock mass, which is projected upwards into the slate. It ends in a wedge-like point. It appears on the east side of a bye-road, passes under it, and is connected with a large mass of the same rock which appears in a quarry, on the west side of the same road.



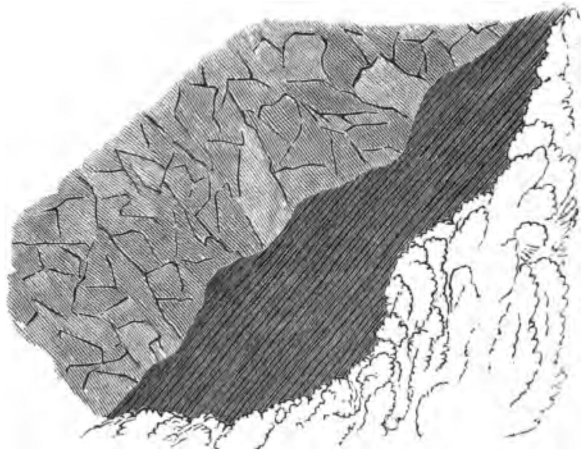
View, Quartz Rock and Slate at Sutton, near Howth,
8 chains North of Martello Tower.

Here the lower mass of quartz rock appears to lie conformably with the slaty strata, but is evidently a projection connected with the overlying rock, and all subsequently to the slate.



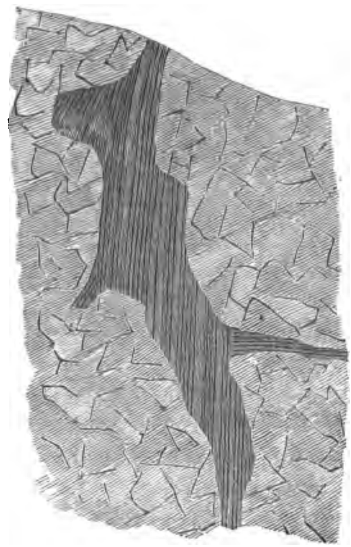
Plan, Slate enclosed in Quartz Rock on the Shore at Sutton, near Howth, 10 chains East of Martello Tower; Scale, 8 yards to an inch.

This sketch shows a piece of gray slate inclosed in quartz rock, and surrounded by it on every side.



View at Sutton, on the Shore North of the Martello Tower, showing Junction of Quartz Rock and Slate.

This sketch shows a mass of quartz rock lying on slate, in a section at Sutton, near Howth. The junction shows an evident unconformability. The slaty beds are broken off, and along the line of junction the quartz rock passes over the broken ends of the strata in an undulating line, although the general line of it is nearly in the strike.



Plan, Gray Slate in Quartz Rock at Sutton, on the Shore, 10 chains East of Martello Tower, Scale 8 yards to an inch.

This sketch represents a piece of slate enclosed in quartz rock. By inspection of the strata in the slate it is evident that the slaty mass has been disturbed; the smaller limbs appear to have been removed from their original position, for the sedimentary lines in them are not parallel to those of the main body.

The foregoing sketches I have selected out of a great number, as tending to show that the slate and quartz rock of the Howth and Bray districts are not now in regular sedimentary succession; but that the whole of these districts has been much disturbed, and in the course of this disturbance the quartz rock intruded into positions in which it was not originally deposited.

The area of the great platform of the Hill of Howth was, no doubt, at one time all covered with the slaty rocks, but they have been mostly carried away, little remaining but a few thin, superficial patches lying in hollows on the surface of the hard, yellow, rocky mass of the hill. All round this mass there must be a fault, along the line of which it was torn away from the corresponding

parts below, and the whole mass elevated to its present position. This, on the north side of the hill, is clear, where the limestone stands now at a low level on the shore, and in the demesne, while the quartz rock of the hill stands about 500 feet higher; the natural position of the quartz rock in the crust of the earth, as seen in Mayo, lying under the slaty rock, being several thousand feet below the limestone.

The same observation applies to all the large circular or elliptic masses of quartz rock in the district, where no slate is seen within the area of such mass to interrupt its continuity.

The thickness of the quartz rock in Donegal or Mayo it is difficult to ascertain, without a more minute survey than I have had opportunity to make. In Wicklow the Great Sugarloaf mountain is, by the Ordnance Survey, 1651 feet above the level of the sea, and the whole mass, from the summit to the base on the east side, is quartz rock, and probably far below the parts visible in the valley of Kilmacannoge. It may be two thousand feet thick or upwards in this locality.

In the counties of Wicklow and Wexford the slate along the margin of the granite for a mile or more in width is highly micaceous; beyond this the micaceous lustre becomes less, and at a few miles from the junction it disappears altogether; and as in Wicklow, so in Donegal, the mica slate of that country is probably the graywacke system altered in that locality. From examples before stated I take the quartz rock of Donegal and Mayo to be the oldest stratified rock we have in Ireland, and the quartz rock of Leinster, that is, Howth, the Sugarloaves, and Forth Mountain, its counterpart; and it is remarkable that in those localities it is associated with the lower part of the graywacke, or what is now called the Cambrian rocks.

While on the subject of quartz rock, it may not be out of place to notice, that our two great formations in Ireland, the old graywacke, and the carboniferous, bear parallel comparisons in many features. Thus the quartz rock in Mayo and in Donegal, clearly lying under the altered slates and limestones of that district, bears a resemblance to the old red sandstone lying at the base of the carboniferous rocks; and the mica slates and crystalline limestones of Donegal, which succeed the quartz rock, may be compared with the shales, limestones, and grits of the carboniferous formation also,—

the great difference being that in the old or graywacke system the quartz rock is excessively hard. The mica slate and the limestone, which is universally crystalline, all appear to have undergone a greater change, being more hard and consolidated than the members of the carboniferous formation, the latter being in general softer and more friable.

As I have just said, I suppose that the Hill of Howth was separated below from the parent quartz rock which lies there still, and was elevated to its present position. An attempt might be made to ascertain the amount of this displacement or upheaval.

In Poulscadden Bay, immediately to the east of Howth Harbour, the quartz rock of the hill is found adjacent to the carboniferous slate of that locality; and no doubt they are in contact, though the junction is not visible, being covered by gravel; thus those two rocks are brought together at Howth by the upheaval of the quartz rock; and as the natural position of this is below the graywacke, the amount of displacement must be equal to the whole thickness of the graywacke group, together with that of the old red sandstone which lies under the carboniferous slate. What, then, is this thickness?

Mr. Robert Harkness read a paper at the late meeting of the British Association on the Graywacke or Silurian rocks of the Grampians, and stated, that in the sections which he examined those rocks were at least 15,000 feet in thickness. Professor Nicol, of the Queen's College, Cork, read another paper on the same subject, but his examination was more extensive, and in a different part of the mountain group. From his observations he inferred that the thickness of the graywacke slates and grits exceeds 30,000 feet, or about six English miles. From sections I know in the county of Londonderry, and also in Cork, I believe this estimate of the thickness of the slaty rocks is not at all above the truth. Therefore six English miles may be taken as the lowest estimate of the amount of the fault in Poulscadden Bay, which brought the quartz rock and carboniferous slate into contact.

I have thus laid before the Society the views I entertain regarding the quartz rocks of Dublin, Wicklow, and Wexford, and hope by so doing that the attention of more able geologists will be drawn to the subject, with a view to the adjustment of such differences of opinion as various observers may adopt concerning those rocks.

May 11, 1853.—Results of an Analysis of Siliceous Deposits from the Hot Volcanic Springs of Taupo, New Zealand. By J. W. Mallet, Ph. D.

Incrustations of a siliceous character occur abundantly around the hot springs of the remarkable district of Lake Taupo, in the northern island of New Zealand, a district of which a most interesting account has been given by Dr. Dieffenbach in his Travels in New Zealand. Indeed, almost all the springs of hot water and mud of this region appear to hold silica in a soluble condition, and to deposit it on the surface more or less mixed with other matters previously dissolved or suspended in the water.

A specimen of one of these incrustations, I believe from the Lake Taupo region, although the particular locality is not stated, was analyzed by Mr. R. Pattison,* with the following results:—

Silica,	77.35
Alumina,	9.70
Peroxide Iron,	3.72
Lime,	1.74
Water,	7.66
	100.17

Whence Damour classes it along with similar deposits from the geysers of Iceland, under the formula 2 SiO_3 + HO, though, if the alumina, peroxide of iron, and lime, be supposed to have been combined with part of the silica, the mineral will be more properly represented as 3 SiO_3, 2 HO. But the presence of so large a percentage of foreign matter renders it difficult to assign any exact formula to this mineral.

The results of an analysis of a purer specimen which I have recently made differ widely from the preceding, and also from the composition of Geyserite from Iceland as given by Damour and Forchhammer. The specimen in question, which was subjected to examination, was a porous but compact concretion, opaque, and of a white colour, slightly tinged with yellow, very tough, and difficult to break, and intermediate in hardness between felspar and quartz. Its specific gravity was 2.031.

Digested in a cold solution of caustic potash it dissolved, though very slowly, leaving scarcely any residue.

* Philosophical Magazine, xxv. 495.

A portion of the mineral was dried at 212°, and then analyzed by fusion with carbonate of soda in the usual way.

Having digested some of the finely pulverized mineral in boiling water, I was surprised to find that on filtering and adding solution of nitrate of silver, a precipitate of chloride of silver was formed, showing the presence of some soluble compound of chlorine. A separate portion of siliceous sinter was then employed for the determination of the chlorine, and having thrown down the chloride of silver, and filtered, the excess of silver was removed by muriatic acid, and the solution again filtered was evaporated to dryness, when the substance in combination with the chlorine proved to be sodium. Nothing but chloride of sodium had been dissolved out by the boiling water, and by testing the portion thus washed it appeared that all the chlorine existed in the same state of combination, and had all been dissolved by the water.

The analysis yielded the following results:—

Silica,	94.20
Alumina,	1.58
Peroxide of Iron,	.17
Lime,	Trace.
Chloride of Sodium,	.85
Water,	3.06
	99.86

If 1.53 per cent. of the silica be deducted as having existed in combination with alumina and oxide of iron (as binary silicates), the relative proportions of silica and water in the mineral will be—

		Atoms.
Silica,	92.67	1.993
Water,	3.06	0.340

numbers which closely approximate to the formula 6 SiO_3, HO. This is much nearer to the composition of some varieties of hyalite and cacholong than to that of any of these recent incrustations of volcanic origin previously analyzed.

The occurrence of chlorine in deposits of this character has not, as far as I am aware, been before noticed, though potash and soda in small quantities have been detected, and were supposed to exist, as they probably often do, in combination with the silica. The ex-

istence of chloride of sodium, therefore, in this incrustation, and in appreciable quantity, amounting to nearly 1 per cent., appears to be a point of some interest, though its bearing upon the chemical geology of these volcanic springs could not be considered without more distinct information as to the nature of the springs themselves, and the circumstances under which the incrustation was formed, than I have been able to obtain.

May 11, 1858.—" On the Geology of Portraine, Co. Dublin;" by HENRY B. MEDLICOTT, Esq., of the Geological Survey.

THE district I have to describe is about twelve miles to the north of Dublin; it is geographically, as well as geologically, isolated. It is bounded on the east by the open sea, on the north and south by two shallow estuaries, on the west I have taken as limits the mail-coach road between Dublin and Drogheda. The railway divides it equally.

The physical features are anything but striking. The boulder clay, and drift gravel, almost conceal everything, and, although their accumulation and subsequent modelling by degradation were much influenced by the position of the harder rock, they now give their characteristic rounded, undulating outline to the whole country.

The ridges of rising ground run nearly east and west, perhaps a little south of east and north of west. In the centre, or at either end of them, there is generally a support of hard rock, which acted as shield or buttress, or as both, in preventing the removal and levelling of the looser materials. The subjacent rock is only seen satisfactorily along the sea-coast, to the north-east, in the railway cutting, and about Donabate. The greatest elevation is near the coast, only 93 feet above low-water mark.

This district has never, that I could hear of, been made the subject of a special investigation. The name Portraine has for years been known to palæontologists as that of a locality for Silurian fossils, but the beds in which these treasures occur have never been described. The only preliminary information I have been able to obtain was from Mr. Griffith's general geological map of Ireland, and from the larger county map of the Government Geological Sur-

vey. On these we see at Portraine the colours purple, red, blue, and green, indicating the existence of Silurian, Devonian, and carboniferous limestone, with trap rocks. I will endeavour to trace out the connexion of these very distant relations, and to describe the peculiar features of each.

The Silurian rocks are only visible on the east, occupying an area of about a mile long by a third of a mile wide, the greater length being along the coast, running N.E. and S.W. (see Map p. 275.) They are nowhere seen in contact with other bedded rocks; the test of superposition thus fails in establishing their seniority; but we have as conclusive evidence in the striking contrast between the circumstances of relation of the igneous masses to them and to the other deposits. The trap covers as much ground as the Silurian rocks. It shows at the surface in four distinct spots, two in the middle of our map, and two on the east; these last may be said to enclose the Silurian beds.

The most general characteristic of the Silurian rocks is that of being highly calcareous. Their strike is N.E. and S.W., with a dip to the S.E. The uppermost beds consist of green, micaceous, exceedingly hard, calcareous grits, the beds being often four and even eight feet thick, with interstratifying beds of a fragmentary yellowish mudstone, which sometimes exhibits a defaced cleavage. Throughout these the stratification is comparatively undisturbed; there are several small slips and some sharp rolls, but, on the south, where they are most developed, and most removed from the intrusive rocks, they are not very complicated, and may have a thickness of about 300 feet. At extreme low water they can be traced up to the greenstone on the north, gradually losing all decision of character.

In the irregularities of the coast we get short sections showing the underlie of the strata. At the point where the deer-park wall reaches the shore, we see the strong grits resting on some broken and twisted beds of limestone and marlstone. The section has almost the appearance of original unconformability. A close examination, however, will show that, although twisted, each of the lower beds is still entire. The phenomenon is the same as that noticed to the Society last year by Mr. John Hamilton, and as I have often seen myself, occurring in the calp, where, in a synclinal trough, the thick limestone beds can be traced in a tolerably regular curve, while the interlying thin shales and mud layers have slid together into every

imaginable form of crumple. In the case of quartz rock this appearance has been mistaken for the unconformability of intrusion. Below the grits no continuous sequence of beds can be obtained, the disturbing action has been so great upon the more yielding materials. On the coast, south of the Martello Tower, we see in many places a thickness of from 20 to 40 feet, made up of the most regular alternation of compact, hard limestone, with a yellowish, imperfectly indurated marlstone; the layers varying in thickness from two to six inches. In places of violent contortion, the limestone bands have been shivered, and the softer layers have been squeezed between the fragments, giving to the mass the appearance of a great breccia. With these thin layers we have occasional thick, regular beds of limestone; fossils occur in both, perhaps more abundantly in the latter. The general dip is still S. E. at all angles. There are several small instances of inverted bedding.

Inland, the only rock which comes to the surface are thick masses of limestone. I am inclined to think that some of the most westerly of these have no representatives on the coast, not only on account of the greater thickness of the whole group in the centre, but also upon lithological grounds; they have a coarsely brecciated character, some a conglomeritic; pieces of shales, grits, highly micaceous limestone, with an occasional quartz pebble, in a pure blue limestone paste: large corals are mixed up with the stony fragments, but do not preserve any definite position in the mass.

All these sedimentary rocks strike into and between the several greenstone protrusions on the N. E., or rather were forced up and twisted by these, the mutual influence producing an endless variety of texture. The greenstone mass at the southern Martello Tower does not seem to have cut up the stratified rocks, but to have diverted the strike of them from S. W. to S. The greater igneous mass on the shore to the N., I would connect with that in the deer-park, and continue in a S. W. direction. I think we have here a clear case of cause and effect, in these igneous rocks having produced the present position of the older palæozoic deposits. May not the main elevation and strike have been caused by the great intrusion on the N. W., and the complicated contortions be chiefly due to the minor masses on the N. E. and S. W.? Whatever more remote cause may have struck out the lines of intrusion, and have given an initial direction to the general strike and dip of the beds, I cannot explain the

further facts of the case otherwise than by the immediate and direct action of the intruded rock. The course of events can have been on this wise: the lower calcareous breccias, with which are associated some layers of ashy aspect, but which may owe this to subsequent alteration, were probably the result of an early display of volcanic agency at Portraine; a period of rest ensued, during which were accumulated those extremely regular layers of mud and limestone, succeeded by the calcareous grits. What more took place we have no means of judging; the next invasion from below produced the state of things we now find. I have no reason for establishing different ages (in the extended sense of the word) for the intrusion of the several igneous masses of the district. In each we find every variety of colour and texture, gray, green, and red; porphyritic, amygdaloidal, flaky, compact, &c.; and each seems to bear the same relation to the sedimentary rocks. The feldspathic ingredient greatly predominates.

Palæontologists refer the Portraine fossils to the lower Silurian formation; many of the species are identical with those from the chair of Kildare, which latter Professor E. Forbes, in a notice communicated to the Society in January, 1848, considered as representative of the Bala group.*

I subjoin a list of the Portraine species mentioned in M'Coy's "Synopsis of the Silurian Fossils of Ireland:"†—

Leptagonia depressa, ...	*Dal. sp.*
Leptæna sericea, ...	*Sow.*
Orthis actoniæ, ...	*Sow.*
" alternata, ...	*Sow.*
" galea, ...	*M'Coy.*
" porcata, ...	*M'Coy.*
" testudinaria, ...	*Dal.*
Spirifer terebratuliformis, ...	*M'Coy.*

Cyathophyllum cæspitosum, ...	*Gold.*
" dianthus, ...	*Gold.*
" turbinatum, ...	*Gold.*

* There are many other points of resemblance between the geology of the chair of Kildare and of Portraine.

† Several of these and many others may be seen in the Museum of Practical Geology, 51, Stephen's-green, Dublin.

Porites pyriformis,	. . . .	*Ehrm.*
Favosites alveolaris,	. . . .	*Blainv.*
„ polymorpha,	. . . .	*Gold.*
Halysites catenulatus,	. . . .	*Linn. sp.*
Syringopora lonsdaleiana,	. . . .	*M'Coy.*

The rock next by position to those we have been describing is a coarse red conglomerate, made up of pebbles, from the size of a goose-egg down, of quartzite and red grit, a typical example of what is familiar to every one as 'old red conglomerate': this, with other reasons, places it on the list of middle palæozoic formation.

I should like not to skip over such an immense period of geological time without attempting, in some degree, to fill the blank in positive evidence by a sketch of what must, from what we now see, have occurred. No doubt Nature was constantly busy producing or destroying; we can only speak with certainty of the latter. The Silurian rocks we have gone over are not such as we know to be of rapid or of local accumulation; they were spread over a wide area before the forces from below placed them in their present position; nor is it probable that the uppermost grit-bed now on the shore was always the last of his race. There was then at one time a vast amount of solid rock covering what we now find. This was all broken up and completely removed before the deposition of the first bank of red conglomerate. If one may speculate upon so remote a cause, it appears likely that the chief energy of the destroying agent was directed from the N. W.; it is only where they have been protected on this side by the tough greenstone that we have any vestige left of the older stratified rocks; but for the timely arrival of the effective screen of gravel we should not have had even this remnant. This supposition might serve, too, as a possible explanation of the position of the red conglomerate, and of the total absence in it of greenstone or of limestone pebbles. This latter fact made me suppose at first that the trap was newer than the Devonian beds, but I searched in vain for a confirmation of the idea. The actual junction of the conglomerate and the greenstone is not exposed; they are seen in several places within a few (from 5 to 20) feet of each other, and exhibit no adequate degree of disturbance or of metamorphic action; there is no intimacy between them, either by intrusion or by interstratification.

The surface of the present Silurian area has not been much altered

since the Devonian period; a very little less of recent denudation would have spared the original covering of red conglomerate; we find huge blocks of it in several places; it is only seen undoubtedly *in situ* in a few. In Newbridge demesne and about Donabate there is a very considerable accumulation; it rests against the greenstone, and has a general inclination to the N. and N. W. Where first seen on the south, in the railway cutting, it has the same inclination and the same relation to the greenstone close by. In Portraine demesne, and immediately north of it, on the shore, it shows itself again, in each case dipping to the N. W. from the greenstone. It has then all the appearance of having been deposited against and upon this reef of trap rocks.

The beds above the red conglomerate are very imperfectly seen; we have but a low, short section in the railway cuttings, and three or four quarries, as all evidence. In the southernmost cutting on the railway there is the following stratigraphically conformable sequence for a horizontal distance of about 500 feet. The lowermost, on the south, is the conglomerate before mentioned, 40 feet (horizontal); on it rest red arenaceous shales, 50 feet; hard, red sandstones, with shale partings, 40 feet; red concretionary marl and crumbling sandstone, 70 feet; a bed of greenish clay, 1 foot; crumbling red sandstone, with shale partings, 80 feet; thick bedded red sandstones, 20 feet; grey and red fissile shales, 30 feet; coarse, yellowish, calcareous and earthy sandstones, 25 feet; hard, siliceous limestone, 2 feet; alternating, thin, hard, and shaly calcareous beds, 20 feet; bed of compact earthy limestone, 2 feet; earthy septarian limestone, indistinctly bedded, 120 feet.

Professor Haughton has allowed me to insert an analysis he made of an average specimen from these upper beds:—

Argil, or insoluble residue, ...	53.77
Carbonate of iron, ...	13.21
Carbonate of lime, ...	33.92
No Magnesia.	
	100.90

This will much assist the general description in conveying an idea of the nature of these rocks.

The dip all through is a few degrees west of north, at angles varying from 10° to 25°; with an average of 18°, the section of 500 feet

long gives at the north end a thickness (supposing the lower beds not to thin out) of 155 feet, and a depth of 159 feet. This does not give a correct idea of the general thickness of the Devonian rocks; thus, in Newbridge demesne, the red conglomerate alone shows for a *horizontal* distance of over 1000 feet;—to continue the section, for the next 400 feet there is no rock seen; we then come upon a low, flat, anticlinal of red and yellowish sandstones, some of them coarse and brecciated; these are seen for about 170 feet; there is then another break for 150 feet, when we come upon a confused appearance, for 140 feet, of hard, red sandstone, a fine breccia of slate and quartz, in a red and gray calcareous paste, and uppermost, a bed of hard siliceous limestone, and one of fine gray marl; the average dip is 20° to N. 20° W.; for the next 200 feet there is no rock *in situ;* then the greenstone. I have given the railway section rather in detail, as it is the clue to the position of the newer rocks.

It is through the first of these short sections that the boundary has been drawn, ranking the upper beds as lower mountain limestone, and the lower ones as 'old red' or Devonian. I have not been able to discover sufficient reason for making here so decided a division; certainly the lower beds are red, and the top ones blue or near it: but even lithologically, there is less difference between the lower arenaceous and the upper calcareo-argillaceous portion of this series than between the latter and the clear blue crystalline beds of the 'lower limestone' group, as seen in the neighbourhood. I think I can by fossils strengthen this relationship. In some of the lower beds of the earthy nodular limestone above mentioned I have found delicate carbonaceous impressions of land plants. Would not this separate these beds more distinctly from the essentially marine deposits of the mountain limestone, which, as seen in this vicinity, chiefly abound in the remains of corallines, crinoids, and palliobranchiate molluscs, uniting them at the same time to the essentially littoral or shallow water-beds, of purely mechanical origin, upon which they rest? I cannot undertake to say what special Fauna the fossils I have found most resemble. I have used them merely as marks; physical impressions would, for the use I have made of these, answer as well as physiological impressions, or as organic remains. In the same bed with the plants I got a *Byssoarca*, M'Coy (*B. lanceolata*); also, an orbicula, very flat, with broad,

deeply-marked, slightly eccentric rings, and a faint impression of what I take to be a fish scale; in an associated, hard, compact bed, a pecten, a modiola (?), and a small orthoceras.

The opinion that these calcareous beds were superior to all the arenaceous beds in the cutting, and their apparent dip under the red sandstones to the north of them, must have been the reasons for putting a fault between, with a downthrow to the south. I hold to the same order of superposition, and dispense with the fault: there may be a slight one, but I had rather not assert it; the conglomerate and greenstone at the base of the section, only 700 feet south of where the fault would be, are at the same level as the other conglomerate and greenstone of the district; there is, moreover, ample room for the beds to come up again between the point of their disappearance and the next rock. This view is confirmed by the fact of this rock being a flat anticlinal of red and yellowish sandstone, which may be the highest sandstone beds of the section to the south,—thus requiring space for only about 50 feet thick of calcareous beds. The bed of limestone and of marl, on the extreme north of the stratified portion of the railway section, I consider an outlier of the beds on the south: it is too insignificant to be noticed on the map. All these strata seem to have been deposited in a trough or basin, against the sides of greenstone, probably on a bottom of contorted Silurians. At the edges we have the coarse arenaceous rocks; in the centre, the calcareo-argillaceous; or, more likely still, these finer beds once overlapped all the lower ones. It is easy to imagine how, in the many elevations, depressions, and other vicissitudes they have gone through, they may have been crushed and shifted into their present position. (See Sect. 2, p. 276.)

To the north of Newbridge demesne, on the road side, there is a quarry of flaggy, earthy limestone, with some hard cherty beds: they dip at about 15° to N. 15° W.: they are only 1100 feet distant from the conglomerate in the demesne, and have altogether the same relation to it, as the upper beds in the railway cutting bear to the conglomerate south of them. Lithologically, they are very similar to these upper beds, and I think they are identified by their fossil contents. In some of the earthy layers I found plant impressions, quite the same as I got before on the railway. If these plant-bearing beds are to be classed with either the rocks above or below them, I would be in favour of the latter: there is no unconfor-

mability, no sudden change of texture, or even of colour: on the contrary, everything is gradual, and the conditions of formation of even the extremes need not have been very dissimilar; no extraordinary circumstances are necessary to account for the red conglomerate,—as coarse a one might be formed in a small lake; and the upper calcareous beds have many indications of the proximity of land.

In the overlying mountain limestone we have a great extent, vertical or horizontal, of a very different type of rock. The transition is not discoverable; the few facts we can collect are in favour of its being a gradual one. There are but three spots where the lower limestone can be well seen: on the southern shore, immediately to the east of the railway, there is a quarry of hard, blue limestone, in thick, regular beds, with an occasional parting of dark indurated shale; they dip N. 30° W. at about 15°, and as one of the greenstone masses is but ten yards north of them, they must have got into their present position by sliding down along a fault. Near the shore, on the north, a little to the west of the railway, there is a small quarry of strong beds of crinoidal limestone, dipping N. at 20°. On the extreme west, just by the side of the coach-road, there are two quarries of clear crystalline limestone, with dark shales, dipping N. 10° W. at 25°. There can be little doubt that these beds once covered all the rocks we have been describing. The whole series seems to indicate a slow, continued subsidence, possibly from a state of Silurian land to that of an open ocean; but such general conclusions, from the examination of so limited a district, are of little worth.

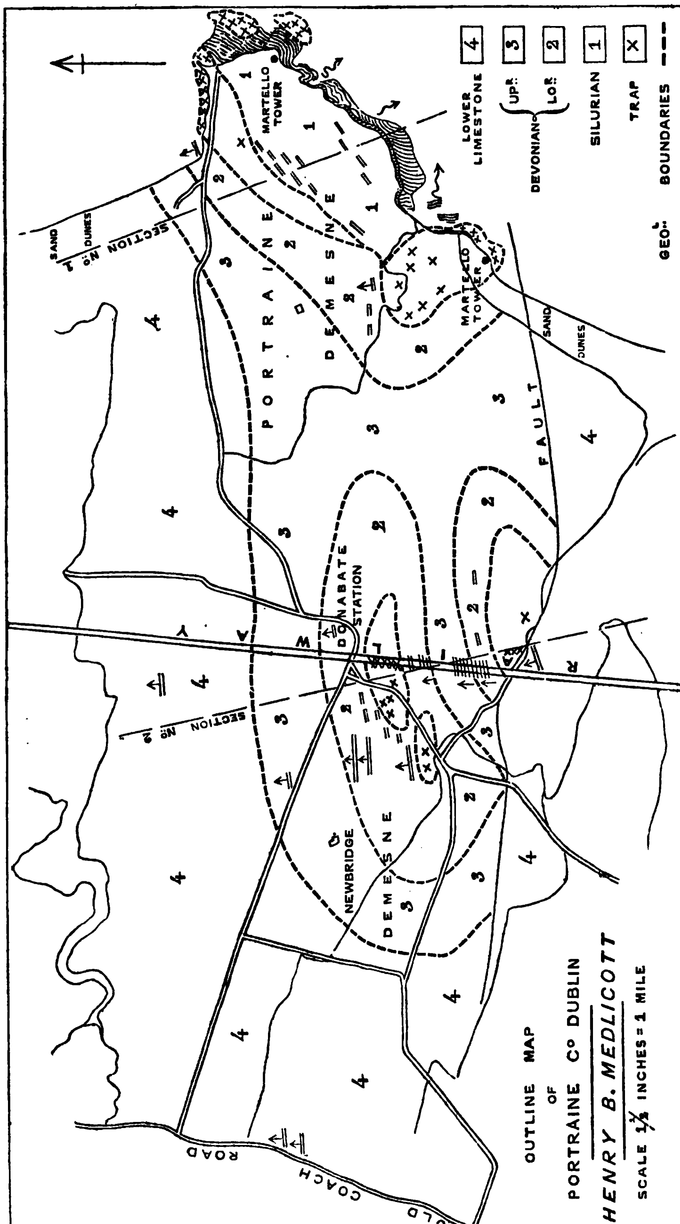
However palæontologists decide upon the fossil contents of the beds in the railway cutting, it does not alter their relation to the red arenaceous beds on which they rest. Considering these last as belonging to the old red or Devonian formation, I have separated the upper beds from the lower limestone group, with which they have been hitherto placed, and given them a separate colour, as upper Devonian; I suppose them to occur in a band round the red sandstones, and to be in turn lost under the mountain limestone. Apart from the unimportant and merely nominal distinction of belonging to the upper Devonian or lowermost carboniferous, this will establish them as intermediate between the more decided types of these two great palæozoic formations.

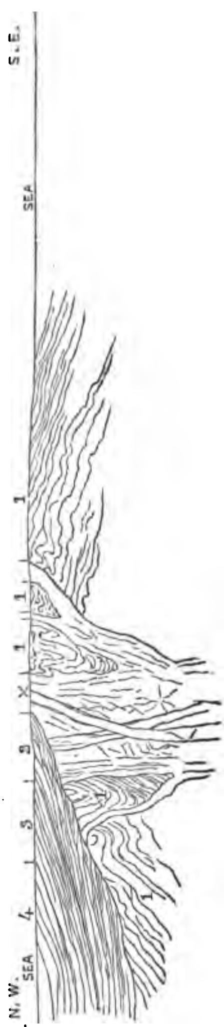
I have not feared, for the inspection of geologists, to draw in boldly the boundaries of the groups between the eastern and middle portion of the district: this space is very low, and deeply covered with drift. There are several possible, and almost equally probable, plans for the outcrop of the rock beneath. There may be greenstone or red sandstone the whole way across; Silurian beds may appear, or, less likely, there may be a tongue of lower limestone. Farming or other operations may put it in the power of some future explorer to settle this question.

The lower limestone in this part of the country occurs in great waves, striking E. and W. Owing to some cause in the latest denudation of the drift, the accumulation has been more on the southern slope of these ridges; hence quarries are opened on the northern, and, consequently, the registered dips are northerly.

The geological description of the island of Lambay ought not to be separated from that of Portraine. The same rocks occur in each, and each would probably assist much in the study of the other. Although only three miles from shore, the difficulty of getting there is such that I did not even make the attempt.

On the outline Map I have made of the district, I have only marked the carriage-roads, water-courses, and principal demesne boundaries. Wherever rock is seen *in situ*, there are parallel strokes in the direction of the strike for the sedimentary rocks, and a small cross for the igneous. The sections are not strictly plotted in any single line, but are compiled so as to represent all the phenomena of the district; they are on a much larger scale than the Map.


OUTLINE MAP
OF
PORTRAINE Co DUBLIN
HENRY B. MEDLICOTT
SCALE 1½ INCHES = 1 MILE
LOWER LIMESTONE
DEVONIAN
UPR.
LOR.
SILURIAN
TRAP
GEOL. BOUNDARIES
MARTELLO TOWER
PORTRAINE DEMESNE
MARTELLO TOWER
SAND DUNES
SECTION No 1
FAULT
DONABATE STATION
RAILWAY
SECTION No 2
NEWBRIDGE
DEMESNE
OLD COACH ROAD



SECTION No. 1.—PORTRAINE DEMESNE AND COAST.

SECTION No. 2.—NEWBRIDGE DEMESNE AND RAILWAY CUTTING.

June 8th, 1853.—"Notes on the Geology of Egypt;" by LORD TALBOT DE MALAHIDE.

IT is singular how little has been done to investigate the geology of Egypt, with the exception of a few mining adventurers, who have been employed by the Pachas in seeking for gold and silver, emeralds, and other precious substances. We are almost dependent on the information contained in the valuable paper of Lieutenant Newbold, read to the London Geological Society on the 29th June, 1842.

It would appear that but few distinct geological formations are represented within its area. The anticlinal axis between the Nile and the Red Sea is chiefly composed of granite, porphyry, and trap rocks, cut through by veins, dykes, and overlaid, in the latitude of Kosseir and Thebes, by the beautiful *breccia verde*.

Whether the section is taken from S. to N. or from E. to W. is nearly the same thing. Next to the crystalline and metamorphic rocks comes a gray sandstone, which, as it is good freestone, was quarried to a great extent at Gebel Silsili by the ancient Egyptians, and is one of the stones most used in the ancient buildings throughout the country. The statues of the Memnon are formed of it. It extends for a great distance to the south of the first cataract, and I believe is found at several intervals along the upper course of the Nile, where the granite and other volcanic rocks do not emerge to the surface.*

Next to the sandstone is a very deep bed of marine limestone. This extends about four degrees of latitude from the vicinity of Esneh to Cairo. It may be divided into two well-marked divisions.

* The most remarkable locality, Gebel Silsili, is thus described in a journal which I kept during my travels in Egypt in the year 1839:—

"The quarries of Gebel Silsili appear to be very regularly and economically worked. The use of the chisel is very evident, and in many places the marks of wedges are visible. The stone appears to vary much in hardness and colour. It is horizontally bedded in thick strata, contains frequent nodules of iron, and occasionally veins of this ore, small seams of calcareous matter, but no organic remains. From the broken appearance of the surface in many places, the large masses scattered about the small ravines extending towards the Nile, and numerous pebbles of quartz and other crystalline rocks, it is evident that currents, or diluvial action, have at one time taken place far above the level of the Nile. I found a small bit of petrified wood on the hills, and also a petrified bone on the shore near the river. Hajar Silsili is an isolated rock, nearly undermined, and strongly resembling the Tors of Dartmoor."

The lower one resembles an indurated chalk, is of a dazzling white colour, and is full of cherty nodules, and a few shells of a large size,—hippurites, echinites, nautili, &c. The upper division seems to be almost a select mass of nummulites: it is of a cream colour, and very often and easily affected by the atmosphere. The great Sphynx and a large proportion of the materials of the great Pyramids are composed of this rock. The harder stratum forms the rocky cliffs of Babel Melouk, at Thebes, and the quarries of Toura, near Cairo, in the east bank, which, from the cartouches carved on the near surface, appear to have been worked from the remotest antiquity, are of the same stone. It is a very good material for carving gigantic figures, and resists better than the sandstone the caustic effects of the magnesia in the sand of the desert. The figure of Rameses II., now half-buried at Mitrahenny, the ancient Memphis, is of this material.* The Egyptian jasper, a very beautiful stone for the lapidary, is found in small nodules imbedded in the limestone on the banks of the Nile, near the island of Philæ. Numerous pebbles of this jasper are found, and the poor labourers traffic largely in them with European travellers.

Above the limestone there is another sandstone, which extends for a considerable distance on the road from Cairo to Suez, and is chiefly remarkable for containing numerous stems of silicified trees, so much so as to give the appearance of a petrified forest.

In the immediate vicinity of Cairo, Gebel Ahmar, in this formation, gives quite the appearance of a small volcano. The form of the ground would support this hypothesis, and the blood-red colour and porous character of the stone would deceive many a superficial observer, and make him suppose that he saw some of the porous kinds of Vesuvian lava. There are fossils found in this stratum, but I have not seen any catalogue of them.†

* The rocks in which the tombs of the Kings at Thebes are excavated are composed of limestone of a very compact character—sometimes *breccia*, sometimes interstratified with shale, and containing nodules of flint in nearly horizontal strata. They are generally globular, and I could not find any trace of any organic substance in the interior. The limestone, however, contains some bivalve shells, and the rock appears quite different in mineralogical character from that of Lower Egypt as far as Beni Hassan. A considerable part of the road is strewn with flints, as on our own downs.

† Rode to the Red Mountain.—The nucleus consists of sandstone, which varies both in hardness and fineness of grain from a pale white to a brick-red colour. It

The most interesting question connected with the geology of Egypt is the age of the great fossiliferous limestone stratum. I believe there is no doubt that it is of the same age as an immense tract extending through Northern Europe to Asia Minor, and from thence to Persia and India. Great difference of opinion has prevailed as to this formation. Continental geologists have generally considered it to belong to the cretaceous system. (See Boué Géologue Voyageur.) It appears, however, to me that Sir R. Murchison, in his elaborate paper on the structure of the Alps, has set the matter at rest, and proved, both stratigraphically and by a discussion of its fossils, that it belongs to the eocene or oldest tertiary series. I produce a few fossils found by myself on the spot—some belonging to the upper part of the bed, and others from the lower stratum near Thebes. I also produce some specimens of the secondary rocks. The granites, basalts, porphyries, &c., are too well known to naturalists to require illustration.

"Geological and Statistical Notes on Irish Mines;" by the Rev. SAMUEL HAUGHTON, Professor of Geology in Trinity College.

No. I.—BALLYMURTAGH SULPHUR AND COPPER MINE.

THE Ballymurtagh sulphur and copper mine is the most westerly of a group of mines, worked on a series of parallel lodes or veins, at both sides of the Ovoca, in the county of Wicklow. The average strike of these lodes is north of east and south of west; in Ballymurtagh itself it is E. N. E. (true bearings), with an underlay south, varying from 50° to 70°. A line of fault appears to separate the mines on the west of the Ovoca from those on the east; the direction of the heave being left-handed, throwing the mines on the west bank of the Ovoca to the south.

The rock of the country is lower Silurian slate, which is gene-

is sometimes very fine, and at other times assumes the character of a decided conglomerate, with flints and chalcedonies imbedded in it. This last quality is the rarest, and generally assumes an irregular appearance of veins. They are slightly inclined from the horizontal line, and appear to me the surest indication of the stratification. There is no appearance of fossils. It has been quarried to an immense extent, and is so still. This mountain is nearly insulated, and the tertiary limestone of G. Mokattem is to be traced in close contact on its flanks.

rally, in the neighbourhood of the mines, of a dark colour, from the presence of hornblende; and frequently assumes the green colour and greasy feel of talcose slate. The Bell Rock, to the south of the mine, is a gray quartz rock, almost infusible, but containing small particles of a dark mineral, which fuse when exposed to a considerable heat. This rock is bedded conformably with the slate, and appears to have undergone considerable metamorphic action, although it is difficult to imagine that it was ever fluxed.

Quartz spar, as might be expected, is of common occurrence in the mine, particularly in the lode called the "Spar Vein." (*Vide* section, p. 282.)

I have found also in the lower levels of the copper lode, carbonate of lime, containing a considerable quantity of magnesia. This occurs in the green greasy slate.

The mines of this district, reckoned from west to east, are,—Ballymurtagh and Ballygahan, on the west of the Ovoca; and Tigroney, Cronebane, and Connorree, on the east. Indications of pyrites exist at each extremity of this mineral district, but not in sufficient quantity to pay for working.

The minerals raised at Ballymurtagh are iron and copper pyrites, which are mixed together in very variable proportions; the quantity of copper pyrites generally increasing as the mine is worked in depth.* The pyrites does not appear to occur in a regular lode or vein with definite walls, but to be diffused through the slate which forms the country in beds, which are stratified conformably with the slate itself; it does not occur pure, but intimately mixed with the slate; the iron pyrites occurs in greatest abundance near the surface of the lode or bed, which becomes richer in copper pyrites as the mine increases in depth.

There are at present five lodes or beds worked on the Ballymurtagh mine, parallel to each other, and conformable to the bedding of the hornblende slate and quartz rock of the district.

These lodes, reckoned from the southern extremity of the townland, are—

1st. The South, or Copper Lode.

2nd. The Pyrites Lode.

* Sulphuret of zinc or blende is also occasionally found to occur in large masses, combined in a remarkable manner with sulphurets of lead and iron.—*Vide* Dr. Apjohn's description, Journal, vol. v., p. 134.

3rd. The Pond Lode.

4th. The North Mine, South Lode.

5th. The North Mine, North Lode.

The first two of these constitute the old mine; the latter are recently discovered lodes, which were not worked until the mine became the property of the Wicklow Copper-Mine Company.

The second, or pyrites lode, joins the first, or copper lode, at about the 56 fathom level, below which there is only one lode, which is worked to a depth of 160 fathoms, the lower part being particularly rich in copper.

The north lode (No. 5) is principally worked for iron pyrites, but occasionally considerable quantities of copper pyrites are found in it; recently a quantity of native copper, 28 lbs. in weight, was found in this mine.

The back of this lode is characterized by a remarkable bed of brown hæmatite, which lies upon the bed of iron pyrites.

A careful analysis of an average specimen of this hæmatite, made by the Rev. Joseph A. Galbraith, gave—

Peroxide of iron,	74·37
Clay and Silica,	11·00
Water,	14·12
Volatile Matter,	0·41
Loss,	0·10
	100·00

The metallic iron in this ore amounts to 52 per cent.; and as it is free from phosphoric acid and sulphur, it is a valuable ore. At the present price of, and demand for iron, this ore would be worth from fifteen to seventeen shillings per ton in South Wales.

No. 1. The copper, or south lode, has been worked extensively from near the surface over an extent of about 200 fathoms long, and down to the 110 fathom level, about 150 fathoms deep.

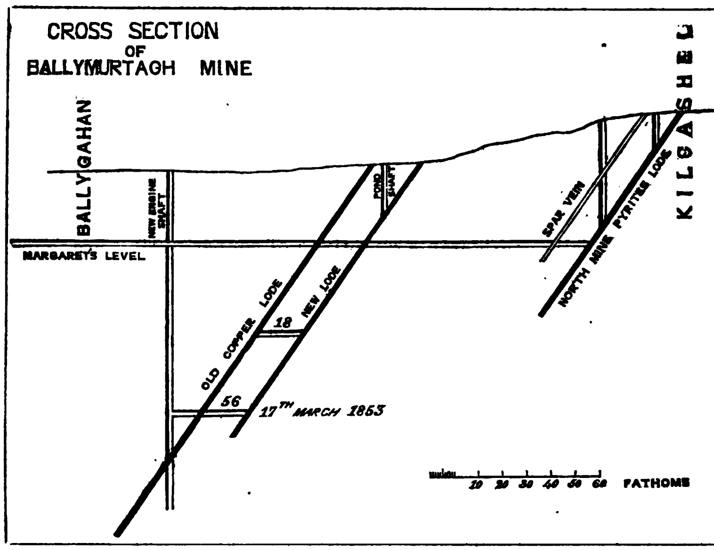
No. 2. The north pyrites lode is opened to 60 fathoms deep, and extended about 70 fathoms.

No. 3. The south lode, north mine, is opened to 30 fathoms deep, and extended 40 fathoms.

No. 4. The pond lode is opened 110 fathoms deep, and extended as under:—

At Margaret's level,	60 fathoms.
At 18 fathom level from north cross-cut,	40 „
At 56 fathom level from north cross-cut,	8 „

About twelve months ago all these lodes were proved in depth by the driving of Margaret's level, which is represented in the annexed section; and still more recently the pond lode has been proved



by cross-cuts from the south mine, at the 18 and 56 fathom levels. This lode has been found, like all the other lodes in Ballymurtagh, to become richer in copper in depth. In driving Margaret's level, a spar vein, 70 feet thick, was cut to the south of the north pyrites lode. This spar was composed of sugary quartz, presenting the vughy appearance which is considered by working miners so valuable as an indication of a mineral lode underneath. The iron pyrites generally occurs in all the lodes near the surface, to the depth of about 50 fathoms, varying in width from 4 to 36 feet, and in hardness and quality in proportion as the ore is mixed with ribs of copper pyrites, or the slate or killas of the country. It contains from 35 to 40 per cent. of sulphur, capable of being used for the manufacture of sulphuric acid: it was proposed as a substitute for brimstone in 1839, in consequence of the high price of that article, occasioned by the greediness of the Neapolitan Government, who had a practical monopoly of the sulphur trade by the possession of the Sicilian sulphur beds.

The first cargo of pyrites, as a substitute for Sicilian sulphur, was sent by the Wicklow Copper-Mine Company on the 28th December, 1839, to Messrs. Newton, Keats, and Co., of Liverpool, the price received for this cargo being 37*s.* per ton of 21 cwt., free on board, the reported produce being 40 per cent. of sulphur, and 1¼ per cent. of copper. The experiment thus tried proved eminently successful, as is shown by the third and fourth columns of the Table, p. 284.

To understand this Table, it should be observed that the ore raised in Ballymurtagh is divided for sale into three classes:

1. Pyrites or Sulphur Ore.
2. Coppery Pyrites.
3. Copper Ore.

1. The sulphur ore contains, on the average, 35 per cent. of sulphur, capable of being extracted.

2. The sulphur copper ores are divided into two classes, the poorer containing about 1¼ per cent. copper, and the richer about 3 to 4; both these classes contain 35 per cent. of sulphur, and are sold to the acid manufacturers, who allow a price for the copper, and send the ore, after being roasted for sulphur, to the Swansea ticketings.

3. The copper ores contain from 3 to 10 per cent. of copper, and are sent direct to Swansea from the mine.

The third and fourth columns contain the total quantities of sulphur ore raised and sold by the Ballymurtagh mine from 1840 to 1852. In 1840 the price at which pyrites could be delivered in England was about 30*s.* to 35*s.* per ton; the corresponding price of brimstone being £12 per ton. Previous to the monopoly in sulphur, the price, taking the average for fifteen years, was £7 per ton. The present price of pyrites is from 20*s.* to 21*s.* per ton, and of brimstone about £6. The capability of the Wicklow mines for producing pyrites is very great, the shipments while the demand lasted in 1841 having been nearly 100,000 tons, producing 40,000 tons of sulphur.

The pyrites vein, or "sulphur course," is what miners call the parent vein or matrix of the lode; it continues, mixed with the copper pyrites, down to the very bottom of the mine, where the copper sometimes reaches 10 per cent. of the ore, and in the shallow work-

ings copper is never totally absent, being generally $\frac{1}{2}$ per cent. even of the pure pyrites lode.

The water issuing from the pyrites workings is strongly impregnated with copper, and on being passed over plates of iron yields a precipitate containing from 10 to 30 per cent. of copper.

An Account *of Ores raised at Ballymurtagh Mine in the following Years:—*

Year ending March	Copper Ore.	Coppery Pyrites.	Pyrites.	Total each year.
	Tons.	Tons.	Tons.	
1834	2821	"	"	2821
1835	5094	"	"	5094
1836	4569	"	"	4569
1837	5666	"	"	5666
1838	6457	"	"	6457
1839	4980	"	"	4980
1840	6706	"	500	7206
1841	3300	"	16423	19723
1842	4779	"	14793	19572
1843	4540	"	11795	16335
1844	5180	"	8363	13543
1845	5056	"	15196	20252
1846	4738	1500	11453	17691
1847	3660	3000	12170	18830
1848	3054	3707	12014	18775
1849	3613	4000	9300	16913
1850	3757	4000	10497	18254
1851	2032	4000	19802	25834
1852	2233	4058	24472	30763
Tons,	82235	24265	166778	273278
Add raisings half year ending September, 1852,	1150	2000	12700	15850
Tons,	83385	26265	179478	289128

The quantity of copper ore raised in the twelve years ending 31st December, 1853, was about 25,000 tons.

As no records or maps exist of the former working of this mine, the early history of it is involved in difficulty,—as all the knowledge

now possessed of the workings previous to 1822 is founded on the verbal statements of old persons, and such data as have been obtained from time to time from the Messrs. Camac and Kyan's accounts.

The Ballymurtagh mine, about eighty-five years ago, was worked by Mr. Whaley, who is said to have made a large fortune from the copper ore raised on the south lode, at depths hardly exceeding 40 fathoms. These old workings, which have been since partially explored, show evident traces of rich branches of ore having been taken away, and subsequently by the application of tutwork and better means of bringing the ore to grass, large quantities of copper ore, of about $7\frac{1}{2}$ produce, were obtained from these old places. Mr. Whaley, besides the advantage of shallow depth, had labour of the cheapest kind, and very high market prices for his ores.

In the year 1780 the workings were resumed by the Hibernian Mine Company, being then about 45 fathoms deep, and drained by an expensive and uncertain system of hand pumps. This Company expended a large capital in more fully opening the lodes, operated largely on the copper as well as the sulphur lodes, when the latter contained a portion of copper, and after erecting calcining and smelting works, making vitriol and precipitate copper, were finally obliged to abandon the concern, after sustaining a large pecuniary loss, about the year 1800.

The mine then lay idle, or nearly so, until 1822, when it was undertaken by a few private individuals, who subsequently formed the Wicklow Copper-Mine Company. During the next ten years the results were uncertain and unsatisfactory, much difficulty arising from the ruinous state in which the mine was left by the Hibernian Mine Company, the continuance of inefficient pumping and drawing machinery, or rather the nearly total want of them. These and other causes retarded the efficient prosecution of the works until the year 1832, since which period the mine has been very successful.

I cannot conclude this short account of Ballymurtagh mine without expressing my obligations to Mr. Edward Barnes, Mining Agent of the Wicklow Copper Mine Company, to whom I am indebted for the information relating to the present state and former working of the mine.

APPENDIX.

TITLES OF PAPERS

READ BEFORE

THE GEOLOGICAL SOCIETY OF DUBLIN.

FROM THE MINUTE BOOKS OF THE SOCIETY.

No. of Paper.	Paper.	Author.	When read.	Page of Minute Book.	Observations.
	Session, 1831-2.				
1	Address delivered at First Annual Meeting of Geological Society,	Rev. Bartholomew Lloyd,	February 8, 1832. .	8	Journal, vol. i. p. i.
2	On Globular Formations, ...	Whitley Stokes, M. D.,	March 14, 1832. .	4	
3	On the occurrence of Peat beneath certain parts of the City of Dublin,	Philip Molloy, Esq., .	April 11, 1832. . .	5	
4	On the Study of Geology in Ireland, ...	Captain Portlock, . .	April 11, 1832. . .	5	Journal, vol. i. p. 1.
5	On the Fossil Deer of Ireland, ...	John Hart, M. D., . .	April 11, 1832. . .	5	Journal, vol. i. p. 20.
6	On the Changes which naturally occur in the Beds and Embankments of Rivers,	Captain Portlock, . .	June 13, 1832. . .	6	See Journal, vol. i. p. 60.
	Session, 1832-3.				
7	On the Conglomerate near the Beach at Kingstown,	Philip Molloy, Esq., .	November 22, 1832.	6	MS. in Library.
8	On the Basaltic District of the North of Ireland,	Captain Portlock, . .	November 22, 1832.	6	Journal, vol. i. p. 71.
9	On the Trap Formation of the County of Limerick,	James Apjohn, M. D., .	December 12, 1832.	7	Journal, vol. i. p. 24.
10	Address delivered at Second Annual Meeting of Geological Society,	Rev. Bartholomew Lloyd,	February 13, 1833.	8	Journal, vol. i. p. 53.
11	On the Identification of Strata, ...	Captain Portlock, . .	March 13, 1833. .	8	Journal, vol. i. p. 75.
12	On Globular Formations (corrected and enlarged, since March 14, 1832),	Whitley Stokes, M. D.,	April 10, 1833. . .	9	Journal, vol. i. p. 15. (Journal has "1832.")
13	On the Evidences of Diluvial Action in the North of Ireland, with Notes by Captain Portlock, and Mr. Bryce's Replies,	James Bryce, Esq., . .	April 10, 1833. . .	9	Journal, vol. i. p. 34. MS. in Library. (Journal has "30th April.")
14	On the Geology of Erris, County of Mayo, . .	P. Knight, Esq., . . .	May 8, 1833. . .	10	Journal, vol. i. p. 45. MS. list of specimens in Library.
15	On the peculiar Porphyry of parts of the County of Antrim,	Lieutenant Stothard, .	May 8, 1833. . .	10	See Third Address, p. 10, which has "3rd May."

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
16	On a Dyke traversing the County of Tyrone, .	Lieutenant Fenwick, .	May 8, 1833. . .	10	See Third Address, p. 10, which has "3rd May."
17	Notes, by a brother Officer, on the Penetration of Mica Slate by Veins of Trap,	Captain Portlock, . .	June 12, 1833. . .	11	
	Session, 1833-4.				
18	On remarkable Boulders of Granite, exposed in the Cuttings of the Dublin and Kingstown Railway,	Rev. Humphrey Lloyd,	November 13, 1833.	12	Journal, vol. i. p. 83.
19	On the Locality of the Fossil Deer, recently discovered in the County of Wexford,	James M'Cartney, M. D.,	November 13, 1833.	12	
20	On the Rocks in the vicinity of Bonmahon, and of the Conglomerate Formation of the County of Waterford,	J. H. Holdsworth, Esq.,	November 13, 1833.	12	Journal, vol. i. p. 85.
21	On the Geology of the District of the Alten Mines, in Finmark,	John Petherick, Esq., .	December 11, 1833.	12	Journal, vol. i. p. 66.
22	Further Account of the Limerick Trap Rocks, .	W. Ainsworth, Esq., .	January 8, 1834. .	13	Journal, vol. i. p. 112. See No. 9. (Journal has "Dec. 11, 1833.")
23	On a Granite Vein traversing Mica Slate, on the Coast of Wicklow,	Robert Graves, M. D., .	January 8, 1834. .	13	Journal, vol. i. p. 69.
24	On a Fossil Plant found on the shore near Carrickfergus,	J. T. Mackay, Esq., .	January 8, 1834. .	13	Journal, vol. i. p. 79.
25	Address delivered at Third Annual Meeting of Geological Society,	Rev. Bartholomew Lloyd,	February 13, 1834.	15	Journal, vol. i.
26	On the Mitchelstown Cave, ...	James Apjohn, M. D., .	March 12, 1834. .	15	Journal, vol. i. p. 103.
27	On a recent Landslip near Larne, ...	James M'Adam, Esq., .	March 12, 1834. .	16	Journal, vol. i. p. 100. MS. of Mr. Hutton's Report on Nos. 26 and 27 in Library.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
28	On the Geological Features of the Peninsula of Fannet, County of Donegal,	James M'Adam, Esq., .	April 9, 1834. . .	16	Journal, vol. i. p. 128. Part of MS. in Library.
29	On an Instrument denominated by him an "Orthoscope,"	Archdeacon Verschoyle,	May 14, 1834. . .	17	MS. in Library.
30	On a Granite Vein in the vicinity of Killiney, .	Rev. Sidney Smith, . .	May 14, 1834. . .	17	
31	On the Bay of Dundalk, ...	Captain Portlock, . .	May 14, 1834. . .	17	Journal, vol. i. p. 246.
32	On Meteorites, ...	Whitley Stokes, M. D.,	June 11, 1834. . .	18	
	Session, 1834–5.				
33	On the Discovery of Granite in the County of Cavan,	Captain Portlock, . .	November 12, 1834.	18	MS. in Library.
34	On the Portrush Rocks, ...	James Bryce, Esq., . .	December 10, 1834.	19	Journal, vol. i. p. 166.
35	On the Elephant's Remains found at Artane, .	Rev. Sidney Smith, . .	December 10, 1834.	19	MS. in Library.
36	On the Bay of Dundalk, ...	Captain Portlock, . .	January 14, 1835. .	20	
37	On a Limestone District north-east of Carlingford,	Major Patrickson, . .	January 14, 1835. .	20	Journal, vol. i. p. 180.
38	On the Mourne Mountains, ...	Lieutenant James, . .	January 14, 1835. .	20	For this and the last Paper, Address (p. 20) has "15th January."
39	Address delivered at Fourth Annual Meeting of Geological Society.	Richard Griffith, Esq., .	February 11, 1835.	22	Journal, vol. i.
40	On the Action of Trap Dykes on Chalk and Sandstone,	James Bryce, Esq., . .	March 11, 1835. .	23	MS. in Library.
41	On the occurrence of Marine Shells, identical with those now existing on the Shore of Dundalk Bay, in Gravel and Sand, which forms the Substratum of a low part of the Country around and under Dundalk,	Captain Portlock, . .	March 11, 1835. .	23	

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
42	On the Magnesian Limestone of Hollywood, and its associated Rocks,	James Bryce, Esq.,	April 8, 1835.	24	Journal, vol. i. p. 175.
43	On the Quartz Rock of Howth,	John Scouler, M. D.,	May 13, 1835.	24	
44	On the Fossils which occur in the Limestone of Kildare,	Rev. Sidney Smith,	June 10, 1835.	26	
45	On the Discovery of a Spring, in the parish of Drung, County of Cavan, issuing from Graywacke Rocks, the surfaces of which, wherever in contact with the water, are encrusted with Calcareous Spar,	Captain Portlock,	June 10, 1835.	26	
	Session, 1835–6.				
46	Account of the Proceedings of the Geological Section of the great Meeting of Philosophers, recently held at Bonn, on the Rhine,	Rev. Sidney Smith,	November 11, 1835.	27	
47	On the relative Ages of the Crystalline Rocks of the County of Antrim,	Richard Griffith, Esq.,	December 9, 1835.	27	
48	On some Fossil Fish discovered by him near Dungannon, County of Tyrone,	Captain Portlock,	December 9, 1835.	27	
49	On the Trap District of the County of Limerick,	John Scouler, M. D.,	January 13, 1836.	28	Journal, vol. i. p. 185.
50	Address delivered at Fifth Annual Meeting of Geological Society,	Richard Griffith, Esq.,	February 10, 1836.	30	Journal, vol. i. p. 141.
51	On the Position of the Gold Mines in Brazil,	F. J. Warre, Esq.,	March 9, 1836.	30	
52	Abstract of his Paper, in Silliman's Journal of Science, on the Extraordinary Magnitude of the Coal Deposits in the United States,	—— Hildreth, Esq.,	March 9, 1836.	30	
53	Verbal Account of the occurrence of Recent Shells in Beds of Alluvium in the vicinity of Dublin,	John Scouler, M. D.,	April 13, 1836.	32	

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
54	On the Mud Volcanoes of Trinidad, ...	Thomas D. Brooke, Esq.,	April 13, 1836. . .	32	MS. in Library.
55	On the occurrence of Marine Shells, corresponding to those of the present seas, at high elevations in the County of Sligo. (Observed by G. Townsend, Esq., about 200 feet above the level of the sea),	Captain Portlock, . .	April 13, 1836. . .	32	MS. in Library; interesting.
56	On Chambered Shells, ...	John Scouler, M. D., .	May 11, 1836. . .	33	
57	On the occurrence of an Insulated Formation of Granite in the County of Cavan, with a Note by Captain Portlock on the same subject,	Lieutenant Stotherd, .	May 11, 1836. . .	33	MS. in Library.
58	On the Connexion between Mineralogy and Optics,	Rev. Humphrey Lloyd,	June 8, 1836. . .	34	Journal, vol. i. p. 210.
	Session, 1836–7.				
59	On the Cervus Megaceros, or Fossil Elk, . .	John Scouler, M. D., .	November 9, 1836.	34	Journal, vol. i. p. 197.
60	Summary of Ehrenberg's Views, which establish a new Coincidence between the State of Nature at remote and in existing Periods,	Sir Robert Kane, M. D.,	November 9, 1836.	36	
61	On Animals which have disappeared from Ireland during the period of authentic history,	John Scouler, M. D., .	December 14, 1836.	37	Journal, vol. i. p. 224.
62	On a Tufaceous Production found near Downpatrick, on the Coast of Mayo,	Captain Portlock, . .	December 14, 1836.	37	
63	On Granite Pebbles found in the Detritus at the base of some of the Tipperary Mountains,	James Apjohn, M. D., .	January 11, 1837. .	38	
64	On the Silicified Wood of Lough Neagh, . .	John Scouler, M. D., .	January 11, 1837. .	38	Journal, vol. i. p. 231.
65	Address delivered at Sixth Annual Meeting of Geological Society,	Colonel Colby, . . .	February 15, 1837.	40	Journal, vol. i.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
66	On a Deposit of Calcareous Tufa in the Queen's County,	C. W. Hamilton, Esq., .	March 8, 1837. . .	41	
67	On the Sources of Carbonate of Lime as a Cement in concretionary masses,	Captain Portlock, . .	March 8, 1837. . .	41	
68	On a native Oxide of Manganese, containing Oxide of Copper, from Sweden,	Professor Davy, . . .	April 12, 1837. . .	42	Journal, vol. i. p. 241.
69	On the Uniformity observable in the older Rocks,	Captain Portlock, . .	April 12, 1837. . .	42	
70	On some remarkable Rocks of the County of Antrim,	Captain Portlock, . .	May 10, 1837. . .	43	
71	On the Limestone of the County of Wexford, and its Geological Relations,	C. W. Hamilton, Esq., .	June 14, 1837. . .	44	Journal, vol. i. p. 313.
	Session, 1837–8.				
72	On the Stratification of the Penrhyn Quarry, North Wales,	C. W. Hamilton, Esq., .	November 8, 1837.	45	
73	Description of Fossils from the Himalaya Mountains,	Thomas Beatty, M. D.,	November 8, 1837.	45	
74	On the Action of Igneous Rocks, ...	Captain Portlock, . .	December 13, 1837.	46	
75	On the Geology of the Dingle District, . . .	C. W. Hamilton, Esq., .	December 13, 1837.	46	
76	On the Mechanism of the Motion of Glaciers, .	Robert Mallet, Esq., .	January 10, 1838. .	47	Journal, vol. i. p. 317. MS. in Library, with Dr. Lloyd's Report.
77	On the elevated Beds of Gravel, containing Shells, in the Vicinity of Dublin,	John Scouler, M. D., .	January 10, 1838. .	47	Journal, vol. i. p. 266.
78	Observations on the Hills called "Eskars," .	Arthur Jacob, M. D., .	January 10, 1838. .	47	
79	Address delivered at Seventh Annual Meeting of Geological Society,	Captain Portlock, . .	February 14, 1838.	49	Journal, vol. i. p. 249. (Journal has "Sixth.")

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
80	On the Origin of Dolomites, ...	John Scouler, M. D., .	March 14, 1838. .	49	Journal, vol. i. p. 382.
81	On the Diluvial or Northern Drift of the eastern and western sides of the Cambrian Chain, and on its connexion with a similar deposit on the eastern coast of Ireland,	Joshua Trimmer, Esq., .	April 11, 1838. . .	51	Journal, vol. i. p. 286.
82	On the Analysis of certain Irish Dolomites, and of a Specimen of Antrim Chalk, altered by contact with protruded Trap,	James Apjohn, M. D., .	May 9, 1838. . .	51	Journal, vol. i. p. 368.
83	On Chromate of Iron, found in the County of Mayo,	—— Smith, ...	May 9, 1838. . .	51	
84	On the Diluvial or Northern Drift of the eastern and western sides of the Cambrian Chain, and on its connexion with a similar deposit on the eastern coast of Ireland (in continuation),	Joshua Trimmer, Esq., .	June 12, 1838. . .	52	Journal, vol. i. p. 335.
	Session, 1838–9.				
85	Address on the Opening of the Session, . . .	Richard Griffith, Esq., .	November 14, 1838.	53	Journal, vol. ii. p. 35.
86	On the Alteration produced in a Conglomerate of the Poikilitic Series, near the Church of Llanfair-is-gaer, in Caernarvonshire, by the contact of a mass of Trap,	Joshua Trimmer, Esq., .	November 14, 1838.	53	
87	On the Euomphalus, ...	Daniel Dowling, Esq., .	November 14, 1838.	54	
88	On the Working of the Newcastle Coal-field, .	Robert Mallet, Esq., .	December 12, 1838.	55	
89	On the Junction of Granite and Mica Slate at Killiney,	John Scouler, M. D., .	December 12, 1838.	55	
90	On the Lead Mines in the County of Clare, .	P. M. Taylor, Esq., . .	. . . .	. .	Journal, vol. i. p. 385.
91	On the Geology of Ayrshire, ...	C. W. Hamilton, Esq., .	January 16, 1839. .	55	

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
92	On the Occurrence of Azote in various Rocks,	Captain Portlock, . .	January 16, 1839. .	55	MS. in Library.
93	On a Bed of Trap in the New Red Sandstone near Belfast,	James Bryce, Esq., . .	January 16, 1839. .	56	
94	Address delivered at Eighth Annual Meeting of Geological Society,	Captain Portlock, . .	February 13, 1839.	57	Journal, vol. ii. p. 1.
95	On the Geological Character of the District between the Dublin and Mourne Mountains,	C. W. Hamilton, Esq., .	March 13, 1839. .	57	Journal, vol. ii. p. 51.
96	On the Fossiliferous Strata in the neighbourhood of Youghal,	Robert Ball, Esq., . .	March 13, 1839. .	57	
97	On the Gold Mines in the County of Wicklow,	Aquilla Smith, M. D., .	April 10, 1839. . .	58	
98	On the Contact of Mica Slate and Limestone at the Rosses, near Sligo,	Archdeacon Verschoyle,	May 8, 1839. (?) .	58	Journal, vol. ii. p. 70.
99	On the Geological Relations of the Slates and Limestones of the Counties of Cork and Kerry,	Richard Griffith, Esq., .	June 12, 1839. . .	59	Journal, vol. ii. p. 78. (Journal has "June 13.")
100	On Fossil Entromostracæ, ...	John Scouler, M. D., .	June 12, 1839. . .	59	
101	On Bogs, ...	Robert Mallet, Esq., .	June 12, 1839. . .	59	
	Session, 1839–40.				
102	On the Geology of the Coast of Louth and Dublin, and the Island of Lambay,	C. W. Hamilton, Esq., .	November 13, 1839.	59	MS. in Library.
103	On the Improvements effected in the Classification and Naming of the Specimens in the Society's Museum,	John Scouler, M. D., .	December 11, 1839.	60	
104	On the Metallurgy of Iron, Copper, Lead, and Tin,	Robert Mallet, Esq., .	December 11, 1839.	60	
105	On some new species of Fossils discovered by him in the Collection of the Society,	Frederick M'Coy, Esq.,	January 8, 1840. .	60	Journal, vol. ii. p. 91. (?)

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
106	On the Magnesian Limestone occurring in the vicinity of Dublin,	John Kelly, Esq., . .	January 8, 1840. .	60	
107	Address delivered at Ninth Annual Meeting of Geological Society,	Richard Griffith, Esq., .	February 12, 1840.	62	Journal, vol. ii. p. 95.
108	On a new Ore of Lead and Antimony, . . .	James Apjohn, M. D., .	March 11, 1840. .	62	
109	On some Fossiliferous Slates in the neighbourhood of Waterford,	Major Austin, . . .	March 11, 1840. .	62	
110	On a new species of Elephant, and some Mollusca,	Frederick M'Coy, Esq.,	March 11, 1840. .	62	
111	On a Substance found in the Substratum of a Peat Bog in the County of Westmeath,	Archdeacon Vignoles, .	April 15, 1840. .	63	If this be the Paper noticed in the Tenth Address (Journal, vol. ii. p. 142), the substance is there stated to have been found in the County of *Kildare*.
112	On the occurrence of Indicolite in the granular white Felspar from the County of Donegal,	Aquilla Smith, M. D., .	April 15, 1840. .	63	
113	On the structure of the Tooth of the Fossil Elephant,	Frederick M'Coy, Esq.,	April 15, 1840. .	63	
114	On some Globular Concretions in Sandstone,	Archdeacon Verschoyle,	May 13, 1840. . .	63	See Journal, vol. ii. p. 134. (Address.)
115	On the Disposition of the Gravel in some Gravel Pits,	C. W. Hamilton, Esq.,	May 13, 1840. . .	63	
116	On Corrections made by him in his Geological Map of Ireland,	Richard Griffith, Esq., .	June 10, 1840. . .	64	
117	On an Analysis of a new Ore of Lead, Sulphur, and Antimony,	James Apjohn, M. D., .	June 10, 1840. . .	64	
118	On the Geology of Connemara, ...	John Scouler, M. D., .	June 10, 1840. . .	65	

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
	Session, 1840–1.				
119	On Lapis Lazuli, ...	Robert Mallet, Esq., .	Nov. 11, 1840. . .	66	Address says "10th June."
120	On Sulphur found in the Limestone of the County of Galway,	James Apjohn, M. D., .	Nov. 11, 1840. . .	66	
121	On the occurrence of Tin-stone at Croghan Kinshela Mountain, in the County of Wicklow,	Aquilla Smith, M. D., .	December 9, 1840. .	66	See Journal, vol. ii. p. 144. (Address.)
122	On the Geology of the Rockabill Islands, . .	C. W. Hamilton, Esq., .	December 9, 1840. .	66	
123	On certain Ochres found in the estate of the Earl O'Neill, in the County of Antrim,	John M'Arthur, Esq., .	January 18, 1841. .	66	
124	Address delivered at Tenth Annual Meeting of Geological Society,	James Apjohn, M. D., .	February 10, 1841.	68	Journal, vol. ii. p. 131.
125	On the recent Formation of some Siliceous Minerals,	Professor Karsten, . .	March 10, 1841. .	68	
126	On some new and rare Fossils found in the Carboniferous Limestone of Clane, in the County of Kildare,	Frederick M'Coy, Esq.,	March 10, 1841. .	68	
127	On M. Agassiz' Work upon the Swiss Glaciers,	Captain Portlock, . .	April 14, 1841. .	69	
128	On the Iron Pyrites or Sulphur Ores of the Ballymurtagh District,	Edward Barnes, Esq., .	May 12, 1841. . .	69	Address has "June."
129	On a method of Analyzing Limestones for the purpose of determining their value for Hydraulic use,	James Apjohn, M. D., .	June 9, 1841. . .	69	
	Session, 1841–2.				
130	On the Changes made in his Geological Map of Ireland, during the years 1839, 1840, and 1841.	Richard Griffith, Esq., .	December 8, 1841.	70	It appears that there was no Paper in November.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
131	On the Carboniferous Slate of the South of Ireland,	Richard Griffith, Esq., .	December 8, 1841. .	70	
132	On some Fossil Crustacea from the Glasgow Coal District,	John Scouler, M. D., .	December 8, 1841. .	71	
133	On the Changes made in his Geological Map of Ireland during the years 1840 and 1841,	Richard Griffith, Esq., .	January 12, 1842. .	72	
134	On the Carboniferous Slate of the South of Ireland,	Richard Griffith, Esq., .	January 12, 1842. .	72	
135	On some Fossil Crustacea from the Glasgow Coal District,	John Scouler, M. D., .	January 12, 1842. .	72	This and the two preceding Papers appear to have been read at last Meeting.
136	Address delivered at Eleventh Annual Meeting of Geological Society,	James Apjohn, M. D., .	February 16, 1842.	72	Journal, vol. ii. p. 173.
137	On some Fossils from various localities in the County of Cork, presented by F. Jennings, Esq.,	John Scouler, M. D., .	March 9, 1842. . .	73	
138	On certain appearances on the surface of Rocks in the neighbourhood of Bantry Bay,	C. W. Hamilton, Esq., .	March 9, 1842. . .	73	MS. in Library. (Interesting, indeed.)
139	On Mr. Griffith's Report on the Presentation of the new Edition of his Geological Map of Ireland,	C. W. Hamilton, Esq., .	April 13, 1842. . .	73	
140	On Quadrumanous Animals, ...	John Scouler, M. D., .	April 13, 1842. . .	73	MS. in Library.
141	On Cirrhipede Mollusca, both Recent and Fossil,	John Scouler, M. D., .	May 11, 1842. . .	74	
142	On certain Rocks described by Mr. Griffith as Chlorite Slate,	C. W. Hamilton, Esq., .	May 11, 1842. . .	74	
143	On Coniferous Plants, both Recent and Fossil,	John Scouler, M. D., .	June 8, 1842. . .	74	
	Session, 1842–3.				
144	On the Proofs of Elevation in the Valley of the Clyde,	John Scouler, M. D., .	November 9, 1842.	76	

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
145	On a Silurian District lately discovered by him north of Ballaghderreen, County of Mayo,	Richard Griffith, Esq., .	December 14, 1842.	76	MS. in Library. Paper says "west" of Ballaghderreen.
146	On the Mastodon Giganteum, with Note by Köch,	John Scouler, M. D., .	December 14, 1842.	76	MS. in Library.
147	On Fossils from Baffin's Bay, ...	John Scouler, M. D., .	January 11, 1843. .	77	
148	Address delivered at Twelfth Annual Meeting of Geological Society,	John Scouler, M. D., .	February 8, 1843. .	79	Journal, vol. ii.
149	On Fossil Botany, with remarks on some Fossils lately presented to the Society,	John Scouler, M. D., .	March 8, 1843. . .	79	
150	On some native Sulphur recently found in Granite in the County of Dublin,	Robert Mallet, Esq., .	April 12, 1843. . .	79	
151	On the Ichthyosaurus, ...	John Scouler, M. D., .	May 10, 1843. . .	80	
152	On Leptæna, ...	John Scouler, M. D., .	June 14, 1843. . .	80	
	Session, 1843–4.				
153	Notice of the Contributions to the Museum of the Society during the Recess,	Professor Oldham, . .	November 8, 1843.	81	
154	On a Series of Horns of the Red Deer found in Ballinderry Lake, in the County of Westmeath,	C. W. Hamilton, Esq.,	November 8, 1843.	81	See Journal, vol. iii. p. 15.
155	Notice of a peculiar form of Quartz from Knockmahon Mines, County of Waterford,	Professor Oldham, . .	November 8, 1843.	81	
156	On Geology as applicable to the delineation of Nature by the Artist,	G. V. Du Noyer, Esq., .	December 13, 1843.	81	See Journal, vol. iii. pp. 16, 17.
157	On a remarkable Structure in the Slate Rocks at Bantry,	George Wilkinson, Esq.,	December 13, 1843.	81	
158	On some Fossil Wood found at a depth of fifty feet in sinking a well at Nenagh, in the County of Tipperary,	George Wilkinson, Esq.,	January 10, 1844.	82	Noticed in Journal, vol. iii. p. 17.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
159	On the importance of Geological Studies in connexion with the practice of Architecture,	George Wilkinson, Esq.,	January 10, 1844. .	82	
160	On a Method of Modelling applicable to copying the remains of the larger Animals,	Robert Ball, Esq., . .	January 10, 1844. .	82	
					Curator's Report comes in here, February 12, 1844. MS. in Library.
161	Address delivered at Thirteenth Annual Meeting of Geological Society,	John Scouler, M. D., .	February 14, 1844.	84	Journal, vol. iii. p. 10.
162	On the Iron Ores of Ireland, ...	Sir Robert Kane, M. D.,	March 13, 1844, .	86	Journal, vol. iii. p. 47.
163	On the relation of Molecular Forces to Geology,	Robert Mallet, Esq., .	March 13, 1844, .	86	Journal, vol. iii. p. 23. MS. in Library.
164	On the Identification of the Hiatella Sulcata, .	C. Fleming, M. D., . .	March 13, 1844. .	86	
165	On the Bones of Oxen found in the Bogs of Ireland,	Robert Ball, Esq., . .	April 10, 1844. .	87	Journal, vol. iii. p. 50.
166	Report on the Fossil Plants in the Museum of the Society,	Professor Oldham, . .	April 10, 1844. .	87	Journal, vol. iii. p. 49.
167	On the Trap Rocks of Limerick, ...	C. W. Hamilton, Esq.,	May 8, 1844. . .	88	Journal, vol. iii. p. 52. Part of MS. in Library.
168	On the Mineralogical Character of Porphyries,	John Scouler, M. D., .	June 12, 1844. . .	89	Journal, vol. iii. p. 58. MS. in Library.
169	On the Rocks at Bray Head, ...	Professor Oldham, . .	June 12, 1844. . .	89	Journal, vol. iii. p. 60.
170	On the more recent Geological Deposits in Ireland,	Professor Oldham, . .	June 12, 1844. . .	89	Journal, vol. iii. p. 61.
	Session, 1844–5.				
171	Notice on the Temperature of Mines in Ireland,	Professor Oldham, . .	November 13, 1844.	89	Journal, vol. iii. p. 72.
172	On some Timber found at a considerable depth below the surface in the County of Tyrone,	William Murray, Esq., .	December 11, 1844.	90	Journal, vol. iii. p. 75.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
173	On the Effects of Compression, as connected with the increase of Temperature as observed in Mines,	Robert Mallet, Esq.,	December 11, 1844.	90	
174	On a Zeolotic Mineral analyzed by him,	James Apjohn, M. D.,	December 11, 1844.	90	Journal, vol. iii. p. 76. MS. in Library.
175	On some Specimens from the Silurian Rocks of Waterford, presented by him to the Society,	Hugh N. Nevins, Esq.,	December 11, 1844.	90	Journal, vol. iii. p. 78. MS. in Library.
176	On the Marbles of Ireland,	George Wilkinson, Esq.,	January 8, 1845.	91	Journal, vol. iii. p. 80.
177	Address delivered at Fourteenth Annual Meeting of Geological Society,	C. W. Hamilton, Esq.,	February 12, 1845.	92	Journal, vol. iii. p. 97.
178	On some new Minerals analyzed by him,	James Apjohn, M. D.,	March 12, 1845.	93	Journal, vol. iii. p. 120.
179	On the supposed Plasticity of Glaciers,	Robert Mallet, Esq.,	April 9, 1845.	94	Journal, vol. iii. p. 122.
180	On the assumed Plasticity of Glacier Ice,	Robert Mallet, Esq.,	May 13, 1845.	95	Journal, vol. iii. p. 125.
181	On the Discovery of Lignite in the vicinity of Belfast,	James M'Adam, Esq.,	June 11, 1845.	95	Journal, vol. iii. p. 132. MS. in Library.
182	On the Gravel and other recent Geological Deposits in Ireland (supplemental to his Paper read June, 1844).	Professor Oldham,	June 11, 1845.	96	Journal, vol. iii. p. 130.
	Session, 1845-6.				
183	On the Movements of Gravel Beds and of Erratic Boulders,	Robert Mallet, Esq.,	November 12, 1845.	96	
184	On the succession of Rocks in the neighbourhood of Killarney and Hungry Hill,	C. W. Hamilton, Esq.,	December 10, 1845.	97	Journal, vol. iii. p. 134. MS. in Library.
185	On the Vorticose Movement assumed to accompany Earthquakes,	Robert Mallet, Esq.,	December 10, 1845.	97	Journal, vol. iii. p. 138.
186	On the Cause of the Disease in the Potatoes,	William Andrews, Esq.,	December 10, 1845.	97	Journal, vol. iii. p. 145.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
187	On the Trap Rocks of Limerick, ...	C. W. Hamilton, Esq., .	January 14, 1846. .	98	Journal, vol. iii. p. 145. (Journal has "January, 1845.")
188	On the Order of Succession of the Strata in the South of Ireland, with particular reference to the Killarney District of the County of Kerry,	Richard Griffith, Esq., .	January 14, 1846. .	98	Journal, vol. iii. p. 150.
189	On the Formation of Lakes on the Flanks of the Commeragh Mountains,	Hugh N. Nevins, Esq.,	January 14, 1846. .	98	Journal, vol. iii. p. 160. MS. in Library. (Interesting.)
190	Address delivered at Fifteenth Annual Meeting of Geological Society,	C. W. Hamilton, Esq.,	February 11, 1846.	99	Journal, vol. iii. p. 168.
191	On Diurnal and Secular Motions of the Earth's Crust, with some Remarks by R. Mallet, Esq.,	Sir W. R. Hamilton, .	March 11, 1846. .	100	Journal, vol. iii. p. 180. MS. in Library.
192	On the Geological Structure of the West Coast of Clare,	G. V. Du Noyer, Esq., .	March 11, 1846. .	100	Journal, vol. iii. p. 187.
193	On Griffithides Globiceps (Portlock), and other Carboniferous Fossils,	Professor Oldham, . .	March 11, 1846. .	101	Journal, vol. iii. p. 188.
194	On the Geology of the neighbourhood of Lisbon,	John Scouler, M. D., .	April 8, 1846. . .	101	Journal, vol. iii. p. 195.
195	On the Marl and Gravel Deposits of the County of Wexford,	Captain James, . . .	May 13, 1846. . .	102	Journal, vol. iii. p. 195.
196	On the Formation of the Fissures of Mineral Veins and Dykes,	Robert Mallet, Esq., .	June 10, 1846. . .	103	Journal, vol. iii. p. 197.
197	On the supposed existence of Moraines in Glenmalur, County of Wicklow,	Professor Oldham, . .	June 10, 1846. . .	103	Journal, vol. iii. p. 197.
198	On the Facts disclosed by the Tunnelling Operations at Downhill,	James M'Adam, Esq., .	June 10, 1846. . .	103	Journal, vol. iii. p. 199.
199	Remarks on the Advantage of a steady and systematic Acquisition of a Knowledge of Facts,	Robert Mallet, Esq., .	June 10, 1846. . .	103	

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	Session, 1846–7.				
200	On some Shells said to have fallen during a thunder-storm in the County of Carlow, on the grounds of Oak Park, near the Town of Carlow,	Robert Mallet, Esq., .	November 11, 1846.	104	Journal, vol. iii. p. 201. (Mr. Lock's letter in Library.)
201	On the occurrence of a small Boss of Serpentine Rock, near Roundwood, in the County of Wicklow,	Professor Oldham, . .	November 11, 1846.	104	Journal, vol. iii. p. 202.
202	On a remarkable Deposit of Tufa in a Bog near Roscrea, in the County of Tipperary,	Professor Allman, . .	December 9, 1846.	104	Journal, vol. iii. p. 203.
203	On the Geological Structure of Glenmalur, in the County of Wicklow,	Professor Oldham, . .	December 9, 1846.	105	Journal, vol. iii. p. 205.
204	On the Copper Ores of South America containing Precious Metals,	Robert Mallet, Esq., .	January 13, 1847. .	105	Journal, vol. iii. p. 205.
205	On an Analysis of Serpentine from Connemara, obtained by Matthew D'Arcy, Esq.,	Robert Mallet, Esq., .	January 13, 1847. .	105	Journal, vol. iii. p. 207.
206	Address delivered at Sixteenth Annual Meeting of Geological Society,	Robert Mallet, Esq., .	February 10, 1847.	107	Journal, vol. iii. p. 215.
207	On the occurrence of a Deposit of Carbonate of Manganese in the County of Clare,	Sir Robert Kane, M. D.,	March 10, 1847. .	108	Journal, vol. iii. p. 237.
208	On the Results of the Fusion of some Igneous and Trappean Rocks from the County of Wicklow,	Professor Oldham, . .	March 10, 1847. .	108	Journal, vol. iii. p. 239.
209	On an undescribed variety of Hyalite from Mexico, presented to the University Museum by Professor Radice,	James Apjohn, M. D., .	April 14, 1847. . .	109	Journal, vol. iii. p. 240.
210	On the occurrence of Syenitic Blocks in the neighbourhood of Bandon,	Professor Allman, . .	May 12, 1847. . .	109	Journal, vol. iii. p. 242.

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211	Observations on Erratic Boulders, ...	Robert Mallet, Esq., .	May 12, 1847. . .	109	Journal, vol. iii. p. 242.
212	On Pseudomorphous Crystals of Mica, . . .	Professor Oldham, . .	June 9, 1847. . .	110	Journal, vol. iii. p. 242.
213	On certain peculiarities in the Lamination of the Slates in the South of Ireland,	Robert Mallet, Esq., .	June 9, 1847. . .	110	Journal, vol. iii. p. 244.
	Session, 1847–8.				
214	On the Sections exposed by the Cuttings of the Dublin and Drogheda Railway, in the portion extending from Dublin to Donabate,	G. V. Du Noyer, Esq.,	November 10, 1847.	111	Journal, vol. iii. p. 252.
215	On a remarkable Group of the Remains of the Irish Elk, and of the Rein Deer, found by Mr. Moss, in cutting a mill lead near Kiltiernan, County of Dublin,	Professor Oldham, . .	November 10, 1847.	111	Journal, vol. iii. p. 252.
216	On the occurrence of a Substance resembling Bitumen, found in a Bog at Cappa, near Enfield, County of Kildare,	G. V. Du Noyer, Esq.,	November 10, 1847.	111	Journal, vol. iii. p. 258.
217	On the Sections exposed on the Dublin and Drogheda Railway from Donabate to Drogheda,	G. V. Du Noyer, Esq.,	December 8, 1847. .	112	Journal, vol. iii. p. 255. (Journal has "December 13.")
218	On the Section of the Rock at the Chair of Kildare,	Professor Oldham, . .	January 12, 1848. .	114	Journal, vol. iii. p. 260. (Journal has "January 14.")
219	On the Fossils of the Silurian Rocks of the Chair of Kildare, and the indications they afford of the age of the Strata in which they occur,	Professor Forbes, . .	January 12, 1848. .	114	Journal, vol. iii. p. 261.
220	On some Stalagmites from the Cave of Dunmore, County of Kilkenny,	Robert Mallet, Esq., .	January 12, 1848. .	114	Journal, vol. iii. p. 262.
221	Address delivered at Seventeenth Annual Meeting of Geological Society,	Robert Mallet, Esq., .	February 9, 1848. .	116	Journal, vol. iii. p. 273.

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222	On the Geology of Part of the County of Wicklow,	Professor Oldham,	March 8, 1848.	116	Journal, vol. iii. p. 301.
223	On the Molecular Changes of Recent Shells,	Robert Mallet, Esq.,	April 12, 1848.	117	Journal, vol. iii. p. 301.
224	On the Drift of the County of Wicklow,	Professor Oldham,	April 12, 1848.	117	Journal, vol. iii. p. 302.
	Session, 1848–9.				No Meetings in May and June, in consequence of the disturbed state of the country.
225	Address on the Opening of the Eighteenth Session of the Society,	Professor Oldham,	November 14, 1848.	117	Journal, vol. iv. p. 1.
226	On some so-called Fucoid Fossils,	Professor Forbes,	November 14, 1848.	117	Journal, vol. iv. p. 20.
227	On the Maps and Sections of the County of Wicklow, published by the Geological Survey,	Professor Oldham,	November 14, 1848.	118	Journal, vol. iv. p. 20. (For this and two last papers Journal has "November 15.")
228	On a General Principle of Constructing Geological Sections,	Robert Mallet, Esq.,	December 13, 1848.	118	Journal, vol. iv. p. 21.
229	On Silurian Fossils,	Professor Forbes,	December 13, 1848.	118	Journal, vol. iv. p. 30.
230	On the Cuttings exposed on the Dublin and Belfast Junction Railway,	G. V. Du Noyer, Esq.,	January 10, 1849.	119	Journal, vol. iv. p. 31.
231	On the Cuttings on the Belfast and Ballymena Railway,	James M'Adam, Esq.,	January 10, 1849.	119	Journal, vol. iv. p. 36.
232	Address delivered at Eighteenth Annual Meeting of Geological Society,	Professor Oldham,	February 14, 1849.	122	Journal, vol. iv. p. 49.
233	On the Changes of the Earth's Figure and Climate, resulting from Forces acting at its Surface,	Henry Hennessy, Esq.,	March 14, 1849.	122	Journal, vol. iv. p. 139.
234	On certain Copper Ores of Australia, presented to the University Museum by Dr. Todd,	James Apjohn, M. D.,	April 11, 1849.	123	Journal, vol. iv. p. 142.
235	On an Analysis of Killinite,	John W. Mallet, Esq.,	April 11, 1849.	124	Journal, vol. iv. p. 142.
236	On the Geology of the County of Carlow,	Professor Oldham,	May 9, 1849.	124	Journal, vol. iv. p. 146.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
237	On the Variation of Gravity at the Earth's Surface, on the hypothesis of its Primitive Solidity,	Henry Hennessy, Esq.,	May 9, 1849. . .	125	Journal, vol. iv. p. 147.
238	On the Geology of the County of Kildare, . .	Professor Oldham, . .	June 13, 1849. . .	126	Journal, vol. iv. p. 150.
	Session, 1849–50.				
239	On the former existence of small Glaciers in the County of Kerry,	John Ball, Esq., . .	November 14, 1849.	128	Journal, vol. iv. p. 151.
240	On the Geology of Howth, ...	Professor Oldham, . .	December 12, 1849.	128	Journal, vol. iv. p. 154.
241	On an Analysis of Mica, ...	W. K. Sullivan, Esq., .	January 9, 1850. .	128	Journal, vol. iv. p. 155.
242	Address delivered at Nineteenth Annual Meeting of Geological Society,	Professor Oldham, . .	February 20, 1850.	130	Journal, vol. iv. p. 167.
243	On the Rocks in the neighbourhood of Balbriggan,	Professor Oldham, . .	March 13, 1850. .	130	Journal, vol. iv. p. 245.
244	On the Variations in Depth in the Tertiary Deposit, as exhibited in Artesian Borings at Portsmouth,	Lieut.-Col. Portlock, .	April 10, 1850. . .	131	Journal, vol. iv. p. 245.
245	On the Geology of a Portion of the Cape Territory. (Communicated.)	Richard Rubidge, Esq.,	April 10, 1850. . .	131	Journal, vol. iv. p. 248.
246	Observations on the neighbourhood of Belfast, with a description of the Cuttings on the Belfast and County Down Railway,	James M'Adam, Esq., .	May 8, 1850. . .	131	Journal, vol. iv. p. 250.
247	On a Tabular View of the Order of Deposition and Geological Succession of the Groups of Stratified Rocks,	Captain R. Smith, . .	May 8, 1850. . .	131	Journal, vol. iv. p. 269.
248	On the Minerals of the Auriferous Districts of Wicklow,	William Mallet, Esq., .	June 12, 1850. . .	132	Journal, vol. iv. p. 269.
249	Supplement to his Paper read May 8, 1850, .	James M'Adam, Esq., .	June 12, 1850. . .	132	Journal, vol. iv. p. 265.

No. of Paper.	Title of Paper.	Author.	When read.	Page of Minute Book.	Observations.
250	On the Effects of Lateral Pressure in producing Contortions in Rocks. (Communicated.)	E. Barrington, Esq., .	June 12, 1850. . .	132	Journal, vol. iv. p. 277.
	Session, 1850–51.				
251	On the Schistose Condition of the Rocks at Bantry Bay, and on the Boulder Clay which in part covers them,	Lieut.-Col. Portlock, .	November 13, 1850.	132	Journal, vol. v. p. 111.
252	On South African Fossils. (Communicated.)	Lieut.-Col. Portlock, .	December 11, 1850.	133	
253	On taking Date as to Priority in a Question of Geological Discovery. (Communicated.)	Robert Mallet, Esq., .	December 11, 1850.	133	
254	On an Analysis of the Nodules discovered in the Schistose Rocks of Bantry Bay,	Rev. J. A. Galbraith, .	December 11, 1850.	133	Journal, vol. v. p. 112.
255	On the Geology of the Counties of Wexford and Dublin,	Professor Oldham, . .	January 8, 1851. .	133	
256	Address delivered at Twentieth Annual Meeting of Geological Society,	Lieut.-Col. Portlock, .	February 12, 1851.	135	Journal, vol. v. p. 9.
257	On the occurrence of Fragments of Granite in Limestone in the County of Dublin,	Rev. S. Haughton, . .	March 12, 1851. .	135	Journal, vol. v. p. 113.
258	On a New Theory of the Central Heat of the Earth, and of the Cause of Volcanic Phenomena. (Title only read.)	Stevenson M'Adam, Esq.,	March 12, 1851. .	135	
259	On the Geology of the South Staffordshire Coal-Field,	J. Beete Jukes, Esq., .	April 9, 1851. . .	136	Journal, vol. v. p. 114.
260	On an Analysis of a Dolomite from Booterstown, County of Dublin,	Rev. Prof. Haughton, .	April 9, 1851. . .	136	
261	On some Fossil Plants from South Africa, . .	Professor Harvey, . .	May 14, 1851. . .	136	
262	On the supposed Original Fluidity of the Earth and other Planets,	Rev. Prof. Haughton, .	May 14, 1851. . .	136	Printed in the Transactions of the Royal Irish Academy, vol. xxii. Science, p. 251.

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263	On a Hair alleged to have been found in the Shale at Comlean Colliery, Queen's County,	Professor Allman, . .	June 11, 1851. . .	137	
264	On an Analysis of a new Mineral brought from Switzerland by the Rev. Professor Jellett,	James Apjohn, M. D., .	June 11, 1851. . .	137	Journal, vol. v. p. 119.
265	Some Remarks on the Movements of Post-Tertiary and other Discontinuous Masses,	Robert Mallet, Esq., .	June 11, 1851. . .	137	Journal, vol. v. p. 121.
266	On a New Method of ascertaining the Depth of the Sea,	Thomas Brien, Esq., .	June 11, 1851. . .	137	
267	Some Remarks on Mr. Haughton's Paper read at the last Meeting,	Lieut.-Col. Portlock, .	June 11, 1851. . .	137	
	Session, 1851–52.				
268	On the Geology of Rathlin Island, ...	Rev. Prof. Haughton, .	November 12, 1851.	137	Journal, vol. v. p. 130.
269	On the Geology of the neighbourhood of the Town of Wexford,	F. J. Sidney, LL. D., .	December 10, 1851.	138	Journal, vol. v. p. 135.
270	On an Analysis of a new Mineral Species found in the Ballymurtagh Mine, Vale of Ovoca,	James Apjohn, M. D., .	December 10, 1851.	138	Journal, vol. v. p. 134.
271	On the Comparison of the Serpentines of Cornwall and Connemara,	Rev. Prof. Haughton, .	January 14, 1852. .	138	Journal, vol. v. p. 136.
272	Address delivered at Twenty-first Annual Meeting of Geological Society,	Lieut.-Col. Portlock, .	February 11, 1852.	141	Journal, vol. v. p. 165.
273	On the Geology of the County of Waterford, .	J. Beete Jukes, Esq., .	March 10, 1852. .	141	Journal, vol. v. p. 147.
274	On a new Mineral Substance resembling the Pigotite of Professor Johnston,	James Apjohn, M. D., .	April 14, 1852. . .	142	
275	Geological Notes on the neighbourhood of Ballyshannon,	Robert Crawford, Esq.,	April 14, 1852. . .	142	Journal, vol. v. p. 159.
276	On the Microscopic Structure of the Mineral resembling Pigotite, described by Dr. Apjohn at the preceding Meeting,	Professor Allman, . .	May 12, 1852. . .	142	

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277	Section of a Cutting on the Drogheda and Navan Railway,	John Hamilton, Esq., .	May 12, 1852. . .	142	Journal, vol. v. p. 161.
278	On the Geology of the neighbourhood of Ardee and Kingscourt, County of Cavan,	John Hamilton, Esq., .	June 9, 1852. . .	143	Journal, vol. v. p. 161.
279	Exhibited some Fossils from Strangford Lough, with a Geological Section of the Locality,	John B. Doyle, Esq., .	June 9, 1852. . .	143	
	Session, 1852–53.				
280	An account of some Limestone Masses found in the Clay Slate and Conglomerate District of Corkaguiny, County of Kerry,	Rev. A. B. Rowan, . .	November 10, 1852.	143	Journal, vol. v. p. 201.
281	An account of the Gangue of Conlig Lead Mine, County of Down,	Rev. Prof. Haughton, .	November 10, 1852.	143	Journal, vol. v. p. 203.
282	On a variety of Iron Ore found in Connemara,	James Apjohn, M. D., .	December 8, 1852.	144	Journal, vol. v. p. 205.
283	On the Extinct Volcanoes of the Eifel, . . .	Rev. Prof. Haughton, .	December 8, 1852.	144	
284	On an Analysis of Euclase, ...	John W. Mallet, Esq., .	January 12, 1853. .	144	Journal, vol. v. p. 206.
285	Notes on the Geology of the Southern Part of the County of Cork,	Walter L. Willson, Esq.,	January 12, 1853. .	144	Journal, vol. v. p. 209.
286	Exhibited a Sandstone Slab, containing Footprints of Cheirotherium Barthii from Thuringia, and a Slab of Micaceous Sandstone from Massachusetts, with Ornithichnites,	Rev. Prof. Haughton, .	January 12, 1853. .	144	
287	Address delivered at Twenty-second Annual Meeting of Geological Society,	Robert Ball, LL. D., .	February 16, 1853.	147	Journal, vol. v. p. 222.
288	On the Leinster Collieries, ...	Arthur Jacob, Jun., Esq.,	March 9, 1853. . .	148	Journal, vol. v. p. 229.
289	Exhibited a Section and Specimens of the Duncrue Salt Mine, County of Antrim,	John B. Doyle, Esq., .	March 9, 1853. . .	148	Journal, vol. v. p. 232.

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290	On the Quartz Rocks of Bray Head and Howth,	John Kelly, Esq., . .	April 13, 1853. .	148	Journal, vol. v. p. 237.
291	On the Siliceous Deposit from the Hot Volcanic Springs of Taupo, New Zealand,	John W. Mallet, Esq., .	May 11, 1853. . .	149	Journal, vol. v. p. 263.
292	On the Palæozoic Rocks as seen at Portrane, County of Dublin,	Henry Medlicott, Esq., .	May 11, 1853. . .	149	Journal, vol. v. p. 265.
293	On the Geology of Part of Egypt, ...	Lord Talbot de Malahide,	June 8, 1853. . .	150	Journal, vol. v. p. 277.
294	On Irish Mines.—Notes on the Ballymurtagh Sulphur and Copper Mine,	Rev. Prof. Haughton, .	June 8, 1853. . .	150	Journal, vol. v. p. 279.
295	On a Peculiarity in the Lead Ore found in the Townland of Annagh, near Castlemaine, County of Kerry,	Rev. Prof. Haughton, .	June 8, 1853. . .	150	

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